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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
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MINERAL RESOURCES

OF THE

UNITED STATES

CALENDAR YEARS
1883 and 1884

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COPPER.

THE COPPER INDUSTRY OF THE UNITED STATES.

By C. Kirchhoff, Jr.

The years 1883 and 1884 have been very trying for the copper-mining and allied industries in the United States. In addition to the great influence upon them of the continued depression in all branches of business in this country, they have passed through an era of complete revolution of the conditions which have affected them during the past decades. The indications of the years 1881 and 1882 have been fulfilled, and from a spirited competition for the home markets the different copper-producing districts of the United States have entered upon a struggle for existence with the makers of the entire world. That contest has not yet ended, and it is a question which has been seriously discussed *pro* and *con* whether the fiercest moments of the fray have yet passed or not. In some respects our producers have been at a great advantage, in others they have struggled against adverse circumstances. The general effect of the sharp competition in all parts of the world has been the usual one of causing an increase in output, the stronger concerns adding to their yield greater quantities than the amounts of metal withdrawn from the supply by the closing of weaker mines, so that the net result has been quite a general increase in the production. The beginning of periods of depression usually causes mines that have been fairly prosperous for years to add to plant. They hope thus to make up for the falling off in the net returns due to lower prices per pound by forcing down general expenses per unit through a larger output, by scaling cost in every way, by reducing wages, and by taking advantage of the lower prices of raw materials and supplies caused by the general depression. Before a mine is closed down, the force disorganized, and the capital invested in it practically abandoned for at least an indefinite period, its reserves are exhausted, all dead work is suspended, and repairs and renewals of plant are neglected. Work is continued, particularly in the case of joint-stock enterprises, until all appeals to the stockholders fail to procure additional funds, and credit is exhausted. The history of mining has taught this over and over again, and the course of affairs, for instance, in the Lake Superior district during the past two years, has abundantly confirmed it. So far as it is possible to do so at a distance, we can trace the same causes at work in other countries through the reports of public companies. Unfortunately, in the case of Chili the fact that the mines are largely in the hands of private firms and families makes it difficult to follow their affairs.

While on the one hand declining prices have driven many mines to greater output, they have on the other hand effectually restricted the development of new enterprises. Those new ventures, and there were many of them, which had not yet been planted on a solid foundation have been forced to suspension or collapse, and nearly all efforts to raise the capital for new enterprises have failed. It is even a question which those interested in many American copper mines may well seriously debate, whether or not it would not be wiser to allow known large reserves of ore in their mines to remain untouched rather than exhaust them without reaping an adequate reward. This may be particularly urged where the deposits themselves are of an uncertain character, where the ore may be expected to change in character in depth in an unfavorable manner, where railroad communications are poor, fuel is excessively costly, or labor still commands exceptionally high figures.

In the face of all the discouraging circumstances of the past two years the United States has forged ahead to the position of the greatest copper producer of the world, and now occupies a leading rank as a contributor of raw material to its markets. This exuberant production at a time of general depression has no doubt reacted directly upon values, and the heavy output of this country is chiefly responsible for the decline of prices. It has been repeatedly urged, not alone abroad, but also by some of our producers, that the strenuous efforts made to swell the product were suicidal; that by an understanding among the leading mines in principal districts the output could be kept in hand, so that the net returns from the sale of smaller quantities at better prices would be as good, if not better, than those now realized. Even preliminary steps taken in this direction have shown that there is no harmony of opinion on the subject. The conviction seems to have been reached by the managers of the largest mines throughout the country that as newcomers in the world's market, on the footing of regular contributors to it, our copper mines must be the aggressors. They are unflinchingly meeting the market and will hold their position in it until either a closing down of the weaker mines in all parts of the world or the long-expected rapid development of consumption overtakes the production and makes an advance in price possible.

American copper goes abroad now in the form of ore, of matte, of black copper, of refined metal, and of electrolytic copper, every important producing region participating in the movement. It is to be regretted that we have not, during the past two years, made any substantial progress in placing the metal in foreign markets in a manufactured form. In the earlier stages of manufacture in our rolling mills rule of thumb reigns supreme, and the practice in mixing alloys and in melting is spoken of as very crude by men of unquestioned authority. It is in the subsequent mechanical process of shaping the metal, in the taste shown in the make-up of the goods, and in their exceptionally high quality, that American rolling mills and brass and bronze manufactories are said by experts to be far in advance of foreign rivals. Our own producers look with some impatience to the time when the home sales will be enlarged by a demand for raw material for manufactures to be exported, which would go hand in hand with lower prices for manufactured goods in this country, and therefore lead to an expanded home consumption. It is not likely that any steps will be taken in this direction until manufacturers feel convinced, first, that the present abundant production is not a passing phase, and secondly, that they will be compensated by a much larger business for the reduction of profits on a smaller turnover. On the first point an intelligent survey of the field will soon carry with it conviction. Individual enterprises in the new districts may have reached their greatest development or may do so in the near future, but enough attention has now been given to the copper resources of the Rocky mountains to warrant the assertion that the virgin ground already explored will make good any decline in other quarters. On the second point hesitation is better founded, and may only be dispelled by competition by new works.

No question has probably been as variously discussed during the constant decline of values as that relating to the capacity of the different mines to outlive low prices. It has been already pointed out that even poor mines will continue to struggle much longer than is generally believed. During the year 1884 there was probably not a copper enterprise in the United States which has not had every item of cost subjected to the closest scrutiny. So far as the Lake Superior mines are concerned it is a comparatively easy matter to arrive at the proportion of the yield in 1883 and 1884 which has resulted in a profit to the mines. Out of the total product in 1883, of 59,702,404 pounds, about 49,500,000 pounds, or 83 per cent., were produced at figures below the market rates, while in 1884 the figures may be placed at 69,250,000 and 54,000,000 pounds, respectively, assuming the average price to have been 11½ cents. It must not be forgotten that the average price realized is lower in reality than the average market rate in this country, because the returns obtained from that part of the yield which is marketed abroad are lower. So far as the other producing regions are concerned, their mines are, with but a few exceptions, in the hands of firms or close corporations, whose business affairs are not a matter open to public discussion. In some important instances, too, the base metal is a mere carrier of the precious metals, or the presence of the latter in the ore is an important factor, thus rendering the producers more or less independent of the market value of the copper. It may be stated, however, without disclosing private affairs, that out of the total product of Montana certainly a very large percentage yielded a profit, and that out of the whole make of Arizona not less than 90 per cent. was placed on the market, in 1884, at remunerative rates. It is not held, however, that these figures represent the maximum figure, because there are a number of other enterprises, great and small, concerning which no data have been available. Viewing it in a different light, it may be said that out of the total output of the United States in 1884 fully 70 per cent. can be put on the market at 11½ cents for Lake Superior copper, and at 10½ cents for other kinds. These prices are very low as an average of the price realized in 1884.

The decrease in dividends during the years 1883 and 1884 furnishes a striking illustration of the pressure of the decline. The profits paid to shareholders of public companies during these years were as follows:

Dividends of copper mining companies.

Name of mine.	1882.	1883.	1884.
Calumet and Hecla (Lake Superior)	$3,000,000	[illegible]	[illegible]
Quincy (Lake Superior)	440,000	[illegible]	[illegible]
Osceola (Lake Superior)	[illegible]	[illegible]	[illegible]
Atlantic (Lake Superior)	[illegible]	[illegible]	[illegible]
Central (Lake Superior)	[illegible]	[illegible]	[illegible]
Franklin (Lake Superior)	....	[illegible]	[illegible]
Copper Queen (Arizona)	125,000	[illegible]	[illegible]
San Francisco (California)	....	2,500	....
United Verde (Arizona)	....	[illegible]	[illegible]

In addition to these published dividends other profits have been distributed to shareholders in close corporations, among which the Montana Copper Company and the Parrot Silver and Copper Company, both of Butte, may be mentioned.

In some instances these dividends were only earned in part by copper mining operations, being in one case the return from sales of lands, and being in more than one concern partly made up by drawing upon reserve funds. On the other hand it is only fair to state that in many other cases profits earned were invested in extension of plant and equipment, in the accumulation of supplies and working capital, and in the payment of interest charges upon debt inherited from former mismanagement.

How much was irretrievably sunk in the opening of mines and the purchase of plant by concerns unable to meet the market, it is impossible to form any correct idea of. Much of the capital thus invested will become productive as soon as there is a recovery of values, as soon as better transportation facilities are afforded, or supplies, fuel, and labor decline as the consequence of a development of the regions in which they are located. There can be no doubt, however, that very large sums of money have been injudiciously expended and may be counted as a dead loss to the investors. In more than one case absurdly high amounts were paid for property, and serious blunders have been made in building unsuitable or inefficient reduction plant.

The years 1883 and 1884 have therefore been far from being prosperous years for the copper industry of the United States. They have, however, fully proved the vitality of the new districts of the West. They have shown how great are the resources of that part of our country, and have laid the foundation of an industry which is capable of considerable expansion still, and is sure to prove highly remunerative in the future. Individual enterprises may decline, and some of the districts now the scene of considerable activity may be robbed of their importance, but enough has been shown during the past few years of prospecting and development to warrant the statement that our copper resources are far greater in magnitude than even the most sanguine were led to believe two years ago. The opening of the western mines may be regarded as the direct result of the rapid extension of the railroads in the Rocky mountains, cheapening the cost of suitable fuel and the shipment of product. Thus far they have not had the leveling effect upon wages which follows an increase of population and a lower cost of living, and in this direction the future may bring relief to many struggling enterprises. In the southwestern tier of Territories the deposits, so far as they are known by development, carry oxidized ores, often of great richness and in large bodies. As yet they have not been opened to such a depth that unaltered ores have been reached, and the questions affecting their future, when that period does arrive, have not yet been brought up. As a general thing it may, however, be stated that from the character of the deposits and of their ore contents their life is not looked upon as being assured for long periods. But there is so much unprospected ground, so much partially opened, that no serious decline is feared. These Territories are not threatened with a repetition of the short-lived early copper excitement of California. Montana's future as a copper-producing section is assured for many years to come. The great mass of the ore is undoubtedly low in grade, comparatively speaking, but it has proved to be unusually abundant, and is handled with skill and enterprise. Besides these prominent regions, well-authenticated reports come from almost every quarter of the Rocky mountains of promising prospects, some of which will unquestionably develop into important producers. It may, therefore, be stated with confidence that taken as a whole the western States and Territories have proved their ability to become great factors of permanent importance in the copper industry of this country and of the world.

In the Lake Superior region the past two years have practically sounded the death knell of many of the smaller mines, and have borne heavily on the future of ventures into which heavy amounts of capital had gone only a few years since, encouraged chiefly by the prospects of remunerative employment through the introduction of modern methods of extraction and ore treatment. A good deal of progress has been made in that direction, and some relief was obtained by a lowering of the cost of supplies and of wages. But the decline was so heavy that the restriction of expenditures could not keep pace with it, and for some time to come new investments in the mines of the region will not be heavy. The larger, more prosperous concerns have been forced to an increased output, and all but a few of them are now able to continue work at least without loss, though not with the phenomenal profits of the past. There is still an enormous amount of unexplored ground which promises to afford the opportunities for a steadily growing industry.

It may be stated in a general way that the Lake Superior mines possess all the elements of stability, while on the whole those of the far West may be looked upon as subject to greater fluctuations individually and collectively, with the exception always of the Montana mines, where the main dependence is upon the cheap handling of large quantities of ores, which under local conditions must be pronounced low grade. It must be clearly understood in regard to the latter that their similarity with certain great mines of Chili makes it a matter of little doubt that greater depth will reveal changes to unaltered low-grade ores. The future can only teach whether the output can then be maintained. In the meanwhile there are very heavy known reserves, and no signs of changes in the character of the ores have appeared.

DOMESTIC PRODUCTION.

The growth in the production of copper in the United States, compiled up to 1884, inclusive, from the best data available, is shown in the following table. It proves in a striking manner how preponderating was, until the past few years, the influence of the Lake Superior district; and again of one great mine in it, the Calumet and Hecla, for more than a decade. In order to point out more clearly how preponderating has been the output of the Lake district from 1847 to 1880, a column has been added giving its percentage of the total product from year to year. It should be stated that the yield of copper from pyrites is not here included.

Production of copper in the United States from 1845 to 1884, inclusive.

Years.	Total production.	Lake Superior.	Calumet and Hecla.	Percentage of Lake Superior of total product.	Years.	Total production.	Lake Superior.	Calumet and Hecla.	Percentage of Lake Superior of total product.
	Long tons.	*Long tons.*	*Long tons.*			*Long tons.*	*Long tons.*	*Long tons.*	
1845 ...	100	12	....	12.0	1866 ..	8,900	6,138	....	69.0
1846 ...	150	26	....	17.0	1867 ..	10,000	7,824	650	78.2
1847 ...	300	213	....	71.0	1868 ..	11,600	9,346	2,276	80.6
1848 ...	500	461	....	92.2	1869 ..	12,500	11,886	5,497	95.1
1849 ...	700	672	....	96.0	1870 ..	12,600	10,992	6,277	87.2
1850 ...	650	572	....	88.0	1871 ..	13,000	11,942	7,242	91.9
1851 ...	900	779	....	86.6	1872 ..	12,500	10,961	7,215	87.7
1852 ...	1,100	792	....	72.0	1873 ..	15,500	13,433	8,414	87.1
1853 ...	2,000	1,297	....	64.9	1874 ..	17,500	15,327	8,984	87.6
1854 ...	2,250	1,819	....	71.1	1875 ..	18,000	16,089	8,898	89.4
1855 ...	3,000	2,593	....	86.4	1876 ..	19,000	17,985	9,000	94.6
1856 ...	4,000	3,666	....	91.6	1877 ..	21,000	17,422	10,975	82.9
1857 ...	4,800	4,255	....	88.7	1878 ..	21,500	17,719	11,373	82.4
1858 ...	5,500	4,088	....	74.3	1879 ..	23,000	19,129	11,728	83.2
1859 ...	6,300	3,985	....	63.3	1880 ..	27,000	22,204	14,140	82.2
1860 ...	7,200	5,388	....	74.8	1881 ..	32,000	24,363	14,000	76.1
1861 ...	7,500	6,713	....	89.1	1882 ..	40,467	25,439	14,309	63.1
1862 ...	9,000	6,065	....	67.4	1883 ..	51,574	26,653	14,788	52.1
1863 ...	8,500	5,797	....	67.0	1884 ..	62,855	30,916	17,812	49.6
1864 ...	8,000	5,576	....	69.7					
1865 ...	8,500	6,410	....	75.4	Total.	[illegible]	378,067	172,901	72.6

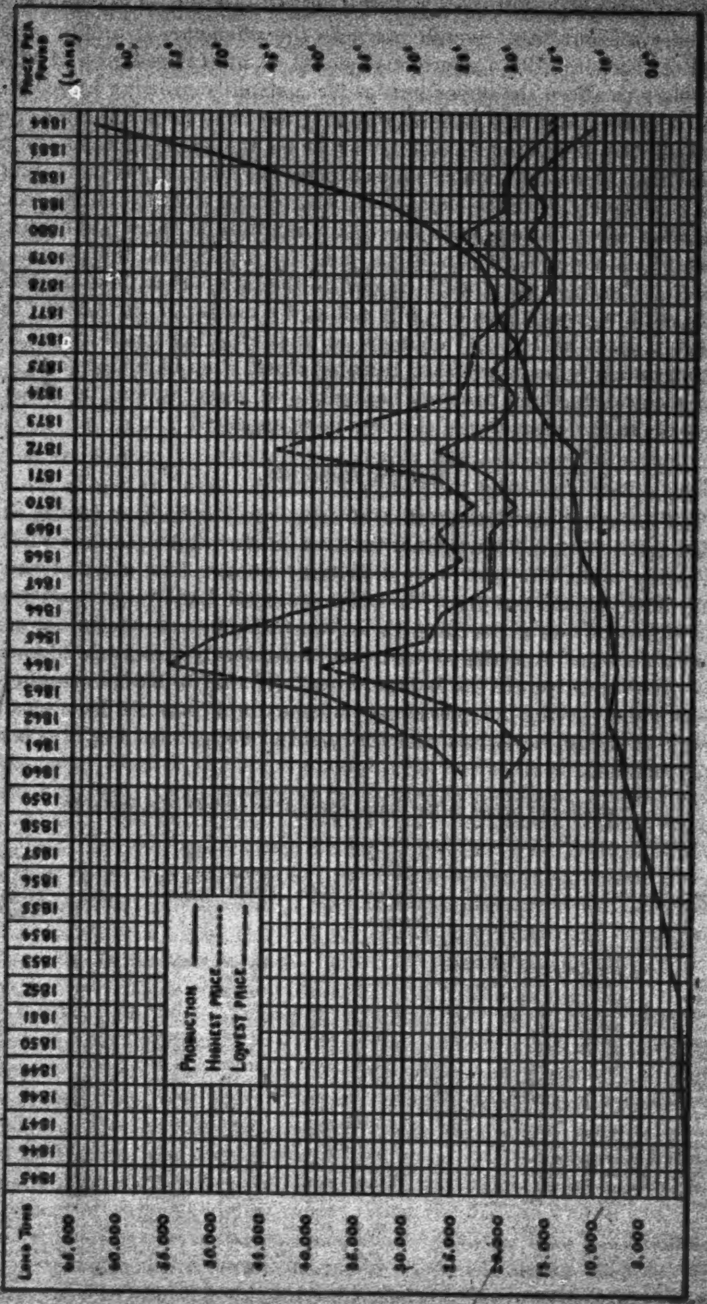

FIG. 3.—PRODUCTION OF COPPER IN THE UNITED STATES, 1845 TO 1884 INCLUSIVE, AND PRICE SINCE 1860.

As in the past, it has been a matter of little difficulty to collect nearly complete returns from the Lake Superior mines. For the year 1883 the official figures by the Hon. A. P. Swineford, commissioner of mineral statistics of Michigan, have been followed:

The production of Lake Superior copper mines in 1882, 1883, and 1884.

Mines.	1882.	1883.	1884.
	Pounds.	*Pounds.*	*Pounds.*
Calumet and Hecla	[illegible]	[illegible]	[illegible]
Quincy	5, 695, 720	6, 012, 200	[illegible]
Osceola	4, 176, 755	[illegible]	[illegible]
Franklin	3, 364, 120	[illegible]	[illegible]
Atlantic	[illegible]	[illegible]	[illegible]
Allouez	[illegible]	1, 751, 577	[illegible]
Pewabic	[illegible]	1, 171, 047	[illegible]
Central	[illegible]	[illegible]	[illegible]
Grand Portage	[illegible]	[illegible]	[illegible]
Conglomerate	134, 240	222, 117	[illegible]
Mass	[illegible]	[illegible]	[illegible]
Copper Falls	[illegible]	[illegible]	[illegible]
Phœnix	[illegible]	512, 291	572, 427
Hancock	[illegible]	[illegible]	[illegible]
Huron	[illegible]	[illegible]	[illegible]
Ridge	[illegible]	[illegible]	[illegible]
Saint Clair	97, 126	[illegible]	176, 619
Cliff	[illegible]	[illegible]	[illegible]
Wolverine	[illegible]	[illegible]	[illegible]
Nonesuch	[illegible]		
Isle Royal	[illegible]		
Minong	[illegible]	[illegible]	
National	[illegible]	[illegible]	
Minnesota	[illegible]	[illegible]	
Belt mines	[illegible]	[illegible]	[illegible]
Sheldon-Columbian	[illegible]		
Aztec	[illegible]		
Adventure	420		
Peninsula		[illegible]	[illegible]
Tamarack		[illegible]	
Ogima		[illegible]	
Total	[illegible]	[illegible]	[illegible]

The figures for 1884 are official estimates. A few small mines have not reported, but their product is not likely to affect the general result to the extent of 60,000 pounds. Estimating their product at about that figure, we reach a total, in round numbers, of 69,250,000 pounds.

Total copper production in the United States in 1882, 1883, and 1884.

Source.	1882.	1883.	1884.
	Pounds.	*Pounds.*	*Pounds.*
Lake Superior	[illegible]	[illegible]	[illegible]
Arizona	17, 984, 415	[illegible]	[illegible]
Montana	[illegible]	[illegible]	[illegible]
New Mexico	[illegible]	[illegible]	[illegible]
California	[illegible]	[illegible]	[illegible]
Colorado	[illegible]	[illegible]	[illegible]
Utah	[illegible]	[illegible]	[illegible]
Wyoming	[illegible]	[illegible]	
Nevada	[illegible]	[illegible]	[illegible]
Idaho			[illegible]
Missouri	[illegible]	[illegible]	[illegible]
Maine and New Hampshire	[illegible]	[illegible]	[illegible]
Vermont	[illegible]	[illegible]	[illegible]
Southern States	[illegible]	[illegible]	[illegible]
Middle States		[illegible]	[illegible]
Desilverization, etc	[illegible]	[illegible]	[illegible]
Total domestic copper	[illegible]	[illegible]	[illegible]
From imported pyrites	1, 000, 000	[illegible]	[illegible]
Total, including copper from imported pyrites	[illegible]	[illegible]	[illegible]

The difficulties of arriving at an accurate estimate of the production in the western States and Territories have been largely increased by special circumstances. There has been a far greater alacrity in making full returns, but notably in the case of Montana producers they are not quite as definite as might be desired, though it must be conceded that often it is difficult for shippers of ore and matte to give a close estimate of the copper contents of the ore or furnace products sold by them. A valuable check upon the direct returns has been obtained through the courtesy of all the refineries, with the exception of one unimportant works.

Since a very large proportion of the total product was marketed abroad in a crude or partly-worked shape, it is practically impossible to make any trustworthy estimate of its value, especially as the payments made for argentiferous material abroad do not specify how much is returned for the one and for the other metal.

It should be noted, in connection with the figures given in this table of production, that a large part of the California, Nevada, and Colorado product, and the greater part of the quantity returned by desilverizers is used for the manufacture of bluestone.

It may be of interest to state that out of the whole domestic product of 1883 of 115,526,053 pounds of copper, no less than 92,500,000 pounds were converted into ingot copper in this country; and that in 1884 the quantity was 108,250,000 pounds out of a total product of 142,363,180 pounds, the decline in the percentage of the total treated in home works being due to larger shipments of ore and furnace material to foreign countries.

Refineries.—The business of copper refining has been practically concentrated in the hands of three concerns, for metal produced in districts outside of Lake Superior. These works are: Pope, Cole & Co., of Baltimore, Maryland; the Orford Sulphur and Copper Company, New York; and the Ansonia Brass and Copper Company, Ansonia, Connecticut. Some refining is also done by the New Jersey Extraction Company, Elizabethport, New Jersey; the Revere Copper Company, Boston, Massachusetts; Taunton Copper Manufacturing Company, Taunton, Massachusetts; and the Harris Copper Company, Sainte Genevieve, Missouri. Messrs. Balbach & Son, of Newark, New Jersey, have during the latter part of 1884 begun to refine argentiferous Montana mattes by the electrolytic process which they have for some time had in use in parting bullion. They convert the matte into blister copper, or work the blister made by the Manhès process. The copper is sold largely for export in the form in which it is stripped from the plates, cut into convenient shapes to suit the views of customers. Early in 1885 the Saint Louis Smelting and Refining Company at Cheltenham, Missouri, has also begun to deposit copper electrolytically.

The Orford Copper and Sulphur Company is regularly working argentiferous material, and Pope, Cole & Co., of Baltimore, also extract silver.

THE COPPER DISTRICTS OF THE UNITED STATES.

Lake Superior.—During the years 1883 and 1884 there have been comparatively few new developments in the Lake mines. New companies, reworking old mines like the Peninsula, the Belt, and others, have either entered the lists of producers or have made preparations for output. A good many of them have been seriously crippled by the unprecedented decline of the metal, which otherwise might have started in their career with fair promise of success. A number of the small mines have already or will in the near future cease operations, and the tendency appears necessarily to be toward the restriction of the make to a comparatively small number of large mines. Copper mining on the lake, reviewing the history of all the old and new mines, has been far from being as remunerative as is generally believed. It is true that the acquirement of the knowledge of the standard methods now in general use has borne a goodly share of the losses, and that many mines abandoned nearly a generation since as incapable of yielding profits would be to-day properties paying regular dividends. But the experience of the past few years is well calculated to discourage, for a time at least, the investment of the very heavy amounts of capital needed, and the Lake region must look to its growth as the leading copper-producing section in the country rather to an extension of the operations of the mines now working at a profit or at least at only a slight loss. The following table, giving the cost of production of the principal mines in the years 1875, 1881, 1882, and 1883, will furnish some means of gauging the capacity to meet the market and of tracing the result of the efforts to reduce the cost. No figures are available upon which it would be possible to base any authoritative estimate concerning the cost price per pound of the Calumet and Hecla mine; but it may be stated that it is certainly lower, excluding construction account, than that of any mine in the list.

Cost of production of Lake copper, per pound.

Mines.	Production (in pounds).		Cost of production, (in cents per pound).					Yield (per cent.)				
	1883.	1882.	1884.	1883.	1882.	1881.	1875.	1884.	1883.	1882.	1881.	1875.
Quincy ...	6,012,[illegible]	5,6[illegible],796	8.[illegible]	9.00	9.55	10.[illegible]	15.79	2.70	2.[illegible]	3.11	2.[illegible]	......
Osceola ...	4,256,409	4,176,782	11.24	12.21	12.97	......	......	1.17	1.21	......	1.[illegible]	......
Atlantic ...	2,[illegible],197	2,621,766	10.[illegible]	12.[illegible]	13.[illegible]	13.[illegible]	22.13	.75	.[illegible]	.[illegible]	.72	.70
Central ...	1,[illegible]	1,[illegible],507	......	15.4	14.76	14.24	15.11	......	1.[illegible]	2.[illegible]	1.[illegible]	2.[illegible]
Allouez ...	1,751,377	1,[illegible],557	13.46	15.[illegible]	17.[illegible]	13.[illegible]	......	.[illegible]	.[illegible]	.[illegible]	.[illegible]	......
Franklin ...	2,4[illegible]	3,2[illegible],120	11.[illegible]	12.96	12.60	......	......	1.4[illegible]	1.3[illegible]	1.10	......	......
Pewabic ...	1,171,867	1,442,[illegible]	......	21.47	17.[illegible]	16.95	......	......	1.61	1.[illegible]	1.[illegible]	......

It will be observed, therefore, that where the conditions affecting the mines remained fairly uniform, there has been a marked lowering of the cost of production at the Lake Superior mines during the year 1884.

This is the result not alone of a scaling down in wages of about 10 per cent., but also by the exercise of the greatest economy in all departments, and of lower prices of supplies, particularly the explosives used. Special efforts have been made in a great many mines to distribute fixed charges over a larger product, by increasing power-drilling and crushing plant. The most extensive work in this direction has been done by the Calumet and Hecla Mining Company, which is now on the eve of the completion of its enormous hoisting and crushing plant. At the mine the entire system of machinery has been so arranged that every motor is practically duplicated to prevent any stoppages. The old mine is opened out, with ground blocked out for years to come, and the vein has been opened to considerable depth at the south end, where practically a new mine has been developed. At the stamp mill Leavitt heads, which admit of a large saving of fuel and an increased capacity, have replaced the Ball stamps, and the mill will during the current year be in a position to crush daily, with ten Leavitt stamps and two in reserve, fully 2,250 tons of rock, equivalent to an annual output of 30,000 tons of ingot. Had it not been for the breaking out of the fire in October, which caused a falling off of the product of about 700 tons, the output would have been 41,300,000 pounds of ingot. At the present rate of nearly 100 tons of mineral per day, next year's yield would be 23,000 tons of ingot, which will, however, be increased as the new equipment becomes available for steady work. The Osceola company has added a fourth stamp; the Allouez, one Ball head; the Atlantic a fifth Ball head, capable of crushing 180 tons per day, and the Huron a second head. The Peninsula company, one of the mines which has entered the ranks of the larger producers, has two Ball stamps, the Conglomerate has three Ball heads, while the Tamarack, a new mine opening the Calumet and Hecla conglomerate at greater depth, has only recently selected a site for its mill. As yet it is impossible to judge whether all of this new equipment will be made to do duty, but the combined additional product of the large companies will probably outstrip the total falling off due to the closing of the weaker mines.

How enormous is the investment of capital needed for the equipment of a Lake Superior copper mine, crushing rock carrying less than 1 per cent. of the metal, is strikingly illustrated by the report for the year 1883, of the Conglomerate Mining Company. In the three years 1881, 1882, and 1883 the company spent $1,288,753.73, or deducting sundry credits, copper sold and on hand, $961,787.06. All but $381,446.02 of this amount is for machinery, plant, railroad, and surface equipment, including $43,072.51 for an air compressor, $145,685.17 for a railroad 7.6 miles long to the mill, $182,047.32 for a new mill, and $44,411.41 for a hoisting engine. The crushing capacity of the 3-stamp mill may be estimated at about 180,000 tons per annum, equivalent, with a fair grade of rock, to a yield of about 1,800,000 pounds of ingot. Mr. Henry C. Davis, president of the Conglomerate Mining Company, has submitted a highly interesting statement giving in detail the cost in 1884, per ton of rock stamped. The figures which are given below would have been materially lower if the cost had been based on the quantity of rock broken.

Cost per ton of rock stamped, Conglomerate mine, 1884.

Mine cost	[illegible]	
Compressor cost	[illegible]	
Pumping	[illegible]	
Hoisting	[illegible]	
Total mining cost, delivered on surface		[illegible]
Handling in shaft houses	[illegible]	
Transportation to rock house	[illegible]	
Breaking in rock house	[illegible]	
Transportation to stamp mill and maintenance of 7 miles of railroad	[illegible]	
Total handling between mine and stamp mill		[illegible]
Stamping and dressing		[illegible]
General surface expenses	[illegible]	
Office and general expenses	[illegible]	
Superintendence and general expenses		[illegible]
Total cost		[illegible]

These figures represent the average for the whole year, stamping 120,844 tons, from which 1,682,080 pounds of mineral or 1,152,224 pounds of ingot were produced. The cost has, however, been considerably reduced during the year. It was $2.139 per ton of rock stamped in January, $1.918 in March, $1.477 in June, $1.274 in September, and $1.288 in October. These figures are of great interest, as showing what a modern plant can do working on conglomerate rock, reaching figures that compare favorably with mines working on amygdaloid; especially since only two of the three stamps were crushing, on an average. The grade of the rock crushed by the Conglomerate appears to have been very low, 0.476 per cent. of ingot, and the mill is now shut down, only a small force being kept sinking to test the ground in depth.

The result of an increase in capacity is clearly illustrated by the figures published in the report for 1884 of the Allouez Mining Company. During the first nine months of the year, while working two heads of stamps, the expenses per pound of refined copper were 15.54 cents. During the last three months with three heads of stamps they declined to 12.43 cents.

The difference between the cost of all-rail transportation of Lake copper, as compared to the rates of water, while lake navigation is open, is not as great now as it was at one time. It is now $5 per ton during the summer and $11.50 during the winter, so that in the case of scarcity in winter the supplies at the refineries could be drawn upon as soon as an advance of one-quarter of 1 cent had taken place. The margin for a speculative profit by concentrating Lake copper in a few hands while lake navigation is closed is not therefore as wide as it was in former times, when advantage was repeatedly taken of it. The charge for smelting mineral is $13 per ton, and that for working slags about $9 per ton—charges against which there has been some agitation.

Taking into account the fact that many of the means of economy practiced have only told during a part of the year 1884, and that more of them will come into play only in 1885, it may be stated that the leading Lake mines have proved their ability to meet the markets of the world and of their competitors in this country. Unless policy dictates a curtailment, of which there is little prospect, the quantity produced will rather show an increase than a decline.

Arizona.(a)—There have been many changes in the list, notably of the smaller copper mines of Arizona. In the Bisbee district the Copper Queen has remained the only producer, the Copper Prince shipping only high grade ore, while the Holbrook and Atlanta mines are being opened up with good prospects. In the Globe district, the Tacoma, Long Island, and others closed down in 1883, and the Old Dominion company was the only one which, favored by the discovery of a large body of high grade ore, was able to stand the strain of low prices of copper and high cost of fuel and transportation. Clifton, where the Detroit and Arizona companies are working, has more than held its own and has the advantage over the other districts of having railroad connections. The Detroit company, managed with ability, has remodeled its smelting works, putting them up at the mines to avoid hauling the ore 7 miles, and has provided a pump and pipe line to force water from the San Francisco river to the smelter, a distance of 31,000 feet and an elevation of 1,500 feet. All the mines are connected with the smelting works by a 20-inch tramway, the ore yielding in the furnaces, inclusive of the low grade iron for flux, 12.5 per cent. The Arizona Copper Company, limited, has also built a new extensive plant, and completed the railroad to Lordsburg, but the mines have not been able to supply the smelter to its excessive capacity with sufficiently high grade ore, and the company, a Scotch concern, has labored constantly with financial difficulties.

Mr. Carl Henrich, M. E., who has studied the Clifton district, protests against the application to this district of the verdict given generally in regard to deposits of oxidized ores in limestone, that they are pockety and liable to exhaustion at any time. He states that the copper deposits of the Clifton district occur either directly at the contact of porphyry and limestone, or in very close proximity to the contact. The ores are classified as ferruginous, calcareous, and manganiferous and siliceous copper ores. Thus far the bulk of the ore smelted has belonged to the first class. The deposits have only been worked in a few instances in a systematic manner, and have been found persistent, and the large number of good prospects encourages the belief that so far as the ore supply is concerned the district will rank as a leading

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a See also the paper by Mr. James Douglas, jr., on "The Cupola Smelting of Copper in Arizona," in this volume.

producer for many years to come. The mines are very dry, and with Mexican labor receiving $2 per day and white miners $3, the cost of mining, deadwork, and hauling to smelter when reasonably near the mines, is estimated at $4.50 per ton. Coke costs $40 per ton, including $12.50 for waste in transportation from San Francisco to smelter. With a modern 14-tuyere furnace, such as that designed and built by Mr. Henrich for the Detroit company, 7½ tons of ore are smelted per ton of coke; putting through 80 tons per day, the total cost of smelting is $7.20. On the basis of these figures, Mr. Henrich estimates the cost of laying down copper in New York, refined, at 10.15 cents for a 9 per cent. ore, 9.44 cents for a 10 per cent. ore, 7.84 cents for a 12 per cent. ore, and 7.14 cents for a 15 per cent. ore. With a smelter like those generally used in Arizona, having a capacity of 35 tons per day, the cost, including a necessarily higher outlay per ton for mining due to smaller production, would be per pound of refined copper laid down in New York, 11.5 cents for 9 per cent. ore, 10.64 cents for 10 per cent. ore, 9.25 cents for 12 per cent. ore, and 7.94 cents for 15 per cent. ore, the allowance for freight and refining being in all cases 2½ cents per pound, which appears ample. Although these figures have not been reached in practice, they indicate that, with careful management, the Clifton mines are in a position to compete at present and even at lower prices.

Turning to the Bisbee district, we have as the leading representative the Copper Queen Mining Company, which has remained the most profitable copper enterprise in the West during the years 1883 and 1884. According to the annual report of the company for the fiscal year ending April 1, 1884, the mine produced during that period 33,961 tons of ore, 33,941 tons of ore being smelted with a consumption of 6,383 tons of coke and 3,617 cords of wood for steam raising. The ore averaged 11.26 per cent. of black copper, the total product of black copper being 7,647,488 pounds, averaging 96.3 per cent. fine. The actual sales of black copper and of ingot during the fiscal year footed up to $1,297,565.63. The net value of the bullion produced at New York was $1,033,045.62, from which are deducted $690,099.55 for operating expenses, freights, refining, and administration, leaving a net profit of $342,946.07. As the dividends aggregated $450,000, the surplus of $267,028.51 on the 1st of April, 1883, was reduced to $159,974.58 on April 1, 1884. On the basis of these figures the cost per pound of ingot copper laid down in New York is 9.40 cents. Since then wages have been reduced, and the cost price has probably declined further.

The Atlanta, a mine adjoining the Copper Queen, has during the past few years opened very large bodies of ore and promises to become an important factor. The Copper Prince, another mine near the Copper Queen, has shipped considerable very high grade ore during 1884, and has accumulated reserves of lower grade ores during development work.

In the Globe district the only company now at work is the Old Dominion Copper Mining Company, which opened out a large body of ore in the Old Globe mine acquired by it, and produced a heavy amount of copper in 1884. During that years 2,336 tons of ore were smelted, which yielded 15.83 per cent. of copper, the ore averaging during that year 17.33 per cent. This high grade has more than compensated for the heavy expense of carrying the coke and supplies to Globe and taking back the metal, and has enabled the company to produce at a profit, even at the lowest prices touched. The other concerns in the district, the Long Island, Tacoma, and others, stopped work early in the year.

The Peabody, acquired by the Cochise Copper Company, in May, 1883, continued working until March, 1884, when the works were shut down on account of the low price of copper. The works produced considerable black copper and some matte.

The Copper Mountain mines consolidated in October, 1884, with the Hartford Copper Company, and the new corporation resumed work on its mines in November. A number of other enterprises were checked in their early stages by the fall in the price of copper, the furnaces either being only partially erected or run only for periods varying from a few days to a month. In some instances the plants have been dismantled and sold. On the other hand new producers have entered the list during the past two years, the most prominent of them being the United Verde, of Jerome, Yavapai county, 30 miles northeast of Prescott, which in 1883 and 1884 paid out $97,500 in dividends. It is the only producer of argentiferous copper in Arizona, and is reported as having large reserves in sight. A second furnace has been built, but smelting operations have been suspended on account of the low price of copper and in anticipation of railroad connections, which it is hoped will be available in July, 1885. Very large quantities of silver are at times contained in the black copper and the matte. Another new enterprise is the Casa Grande Copper Company, which is situated in the Casa Grande district, 40 miles southwest of the railroad. The mine has been opened to a depth of 200 feet, the ore being oxides and carbonates, averaging 12 per cent. Two furnaces have been erected, only one of which has been running, owing to a lack of water, until November. Lately the production has been suspended through lack of ore.

Montana.[a]—The reticence of some of the producers, among them the largest in the Butte district, has made the collection of statistics for 1884 a particularly difficult matter. For 1883, however, the data are nearly complete, since every mine sent either full data or estimates which allowed of a close approximation. An effort has been made to arrive at a satisfactory estimate, in spite of the refusal to give information. From the returns of the railroads giving shipments of ore and matte it has been possible to closely approximate the quantity sent to market by the Anaconda mine, the figures of other important shippers being known. A check upon them, of some value, was furnished by the statement of the exports of this country, although it does not specify the quantities of matte sent abroad. Then, on the other hand, the returns of American refiners of copper giving the quantity of fine copper produced from Montana material was of great service. The quantities thus arrived at are lower than those indicated by the estimates of receipts of fine copper from American ores in England. It is believed, however, that the latter include Mexican ores, chiefly from Lower California, shipped from San Francisco. A matter which makes all such estimates precarious is the fact that the grade of the shipping ore varies within wide limits. It must be noted, however, that one shipper reports that 11,000 tons sent abroad through him averaged 25 per cent. of copper, which is considerably lower than the general average assumed. Under the circumstances the production reported is as close an estimate as a cautious and thorough examination of the facts available could make it. It is unfortunate that important interests should refuse data especially at a time when an excitement produced by exaggerated reports has done much to unsettle values. Uncertainty in such contingencies is worse than the truth, even if the latter presents an unexpectedly unfavorable state of affairs.

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[a] See also the paper by Dr. E. D. Peters, jr., on "The Mines and Reduction Works of Butte City, Montana," in this volume.

As for the immediate future of the copper production of Montana one important fact must not be left out of consideration. The heavy shipments of rich ores may be expected to decline very rapidly and its output will henceforth depend more upon the quantities of matte produced at local smelting works by the treatment of low-grade ores previously concentrated. It becomes therefore more a matter of the capacity of the works. Most of them have been enlarged during 1884, and the largest has not yet, at the close of the year, worked long enough to allow of anything but approximations of its possible maximum output. This undoubtedly is very heavy, but it remains to be seen whether the estimates made can be accomplished in actual work. If the plants now in operation can be run continuously with ores of the same grade as that hitherto treated, the record of 1884 will be outstripped.

An opinion which has been gaining ground is that all of the Butte ores carry paying quantities of silver. If correct, this would put the district into a much more favorable position than it really is. Such is not the case, however. On the contrary, indications point in the other direction; that, in reality, a smaller proportion of the ore is sufficiently silver-bearing to carry the matte produced within the limits of profitable extraction. Some data as to the silver contents of mattes has been furnished, but they are not complete enough to allow of the presentation of any specific figures. The question is one which influences the prices realized very considerably, and therefore affects the capacity of Butte copper mines to resist low prices.

The other factors affecting the cost of production are cost of labor, fuel, and transportation. On the first point the following figures of wages may be submitted: Miners, $3.50 per day; laborers, $3 per day; furnacemen, $4; foremen, $5 to $5.50; carpenters, $5 to $6; and masons, $6 to $8. Several attempts were made late in 1884 and during January, 1885, to force a lowering of wages, but unsuccessfully. Fuel was lowered during 1884, and coal is now purchased for $8 to $9 and coke for $16. Freights to Missouri points are about $20; to the Atlantic or Pacific, $23; and to Liverpool, $25 per ton, since reduced to $18. During 1884 considerable ore, in all about 4,000 tons, was sent via San Francisco and Cape Horn to Europe. At current figures for labor, fuel, and freights, the profit in concentrating and smelting copper ores carrying from 12 to 14 per cent., and little silver, is very small indeed; and it is reported that, in some cases, there is an actual loss. Returns on the basis of 9 shillings per unit, in England, leave practically nothing for the miner in shipping ore running 25 per cent. of copper.

Technically, the Butte copper industry made considerable progress in 1884. A matter which has attracted considerable attention has been the bessemerizing of copper matte at the Parrot works. It is reported that the concentration of the matte has been successful, that the elimination of the arsenic is almost perfect, but that, on the other hand, the losses of silver are heavy.

In the beginning of December the Anaconda and Saint Lawrence miners were sending to the concentrating works about 300 tons of ore carrying about 14 per cent. of copper, and were supplying the furnaces about 100 tons per day of smelting ore averaging about 24 per cent. of copper. The concentrates yielded, by working from 200 to 500 tons of 14 per cent. ore, 30 per cent of copper, which goes to the roasting furnaces. The latter were putting through 10 tons per day, an excessive quantity, since the sulphur contents remained as high as 12 to 14 per cent.

The matting furnaces are rated at a capacity of 5 tons of matte per day, with a fuel consumption of 5 tons of coal per day. This would give the plant a capacity of 130 tons of matte per day, carrying about 60 per cent. of copper and 18 ounces of silver; but the furnaces were not kept running continuously, and during November and December they were turning out from 70 to 80 tons of matte per day.

The Anaconda works consist of a concentrator having 12 sets of rolls and 72 jigs, the capacity of which was rated at 500 tons, but which will not, when it gets into full running order, exceed 400 tons per day of concentrating ore. The smelting plant includes 26 calciners and 26 matting furnaces, to which are being added 12 new hand roasting furnaces. There has been in contemplation the erection of a new concentrating works equal in capacity to the one now running, but the last proposition is to put in a large compound engine to assist the present water-power, and in this manner make the most of the plant. A new addition to the smelting plant of 6 calciners is building. It is estimated that when these contemplated extensions are completed in the course of the year, the plant will have a capacity of 160 tons of matte per day. How far these expectations will be realized remains to be seen. It is urged that the railroad facilities of the works are not equal to hauling the enormous amount of ore which such a product would represent. On the other hand the plant has thus far been at work only three months in 1884, and it is impossible at this time to judge from its record what its achievements will be when the entire working is systematized. It is estimated by persons well qualified to judge that even when strained to full capacity the Anaconda will not in 1885 turn out more than 28,000 to 30,000 tons of matte, equivalent to about 25,000,000 to 36,000,000 pounds of fine copper.

It is just to state in this connection that the above data are not official. They have been gathered from various sources and are presented in the absence of official statements as the best information available. Since the Anaconda works were built they have been very much improved and are now pronounced by leading metallurgists to be fully up to the best practice. The mine has become so great a factor in the position of the copper supply that as close an approximation as possible to an estimate of its capacity is so important that such details as are available should be presented. The mine itself is generally pronounced an exceptional one, and it is believed that with the best machinery and plant it is good for a much larger yield than 600 tons daily for a number of years. The investment in development and equipment has been very large, and so far as the latter is concerned has not at first come up to expectations. Good authorities place the limit of cost, at the prices of labor and fuel at the close of 1884, at about 7¾ to 8 cents, below which only reductions in the items mentioned can force it.

The Montana Copper Company has made large developpments in the East and West Colusa and in the Original Parrot mines. The plant has been enlarged during 1884, and now consists of two concentrating mills, each with a capacity of 75 tons of ore per day, one being used for the Parrot ores and the other for the argentiferous Colusa ores. The smelting works have twelve reverberatory calcining furnaces, six reverberatory matting furnaces, each capable of turning out 2 tons of fine copper daily, and one blast furnace for ferruginous ores, which produces 4 tons of fine copper daily. The policy followed during the year 1884 has been to extract those ores carrying larger quantities of silver, leaving those lower in silver though high in copper untouched, with a view to overcoming the low price of copper with the aid of the silver. In the future more copper ore lower in silver will be extracted, and the output of the works will be increased accordingly. In 1884 the matte averaged about 44 ounces of silver per ton of fine copper.

The Parrot Silver and Copper Company has two concentrating plants, one of 100 tons and the other of 250 tons daily capacity. It has an older plant of six calciners, capable of roasting daily 8 tons per furnace, and six new calciners, each 64 feet long and 13 feet wide, which work 11 tons per day each, with a consumption of wood of 2 cords per twenty-four hours. It has an older matting plant of six reverberatory furnaces with a daily capacity of treating 16 tons of ore per day, and a new plant, consisting of an 80-ton blast furnace provided with a large well from which the molten matte is tapped directly into a Manhès converter, which has been in successful operation during the last months of the year making blister copper free from arsenic from a rich matte, at the expense, however, of heavy losses of silver. The ore has not been running up to average, owing to the fact that a different system of stoping has been adopted. The matte carries on an average 30 ounces of silver per ton.

The Ramsdell-Parrot mine has shipped considerable ore to local smelters, which it is reported averaged about 20 per cent of copper and 16 ounces of silver. It has recently improved its hoisting facilities.

The Bell company has a plant capable of treating 20 tons of 16 per cent. ore daily, making 55 per cent. matte, equivalent to 1,000 tons of copper per annum.

The Clark's Colusa has recently started a small concentrating plant and has a blast furnace on the ground. No data as to its capacity are at hand, and information concerning its output has been declined.

The works of the Colorado and Montana company treat ores particularly rich in silver, making a high-grade matte which is shipped to the Argo works of the Boston and Colorado smelting company. The quantity of copper made is comparatively small, and goes into other channels than the bulk of the Montana product.

New Mexico.—The low prices of copper have caused the cessation of almost all work. The most important mine is the Santa Rita, which has produced considerable quantities of very pure native copper in the past, and is fully equipped to begin work as soon as values recover. Other properties, notably the San Pedro, have been tied up by litigation.

California.—The principal producer in this State is the San Francisco Copper Mining Company, whose mines are at Spenceville, Nevada county, for details concerning the working of which I am indebted to Mr. John E. Ellis. The ore, of which about 75 per cent. has been extracted from an open cut and the remainder from the 150-foot level immediately below it, is a cupriferous pyrites, containing on an average 3½ per cent. of copper, 46.5 per cent. of sulphur, and 42.8 per cent. of iron, the balance being silica and traces of zinc and gold. In 1884 the quantity of ore hoisted was smaller than usual, being about 11,481 tons, since a considerable amount on fire in piles was carried over at the beginning of the year, and a great deal of dead work was done in opening the lower level, which is now in shape to produce regularly. From July to October, both inclusive, the precipitating works were rebuilt. After roasting in open heaps, the ore is leached in 40 wooden tanks 8 by 8 by 4 feet, the water being heated by steam. The resulting solution is run into large settling vats, where the percolations of the dump pile also accumulate, and from whence it is pumped into four revolving cylinders, 16 feet by 6 feet in diameter, which are charged with scrap iron for precipitation. Mr. Ellis states that mining in the open quarry, including hand breaking of ore and conveying to open heaps, costs on an average 35 cents per ton, and underground mining 90 cents to $1 per ton. The labor employed consists of four engineers, at $3 per day; two cylinder men, at $2.50; one blacksmith, at $3.50; one helper, at $2; one carpenter, at $3.50; six miners, at $3 per day; one man at leaching tanks, at $2.50; a foreman for the Chinese labor at the open heaps, at $3; one laborer for sacking precipitate, at $2; one teamster at $2, and thirty-five Chinese laborers, at $1.20 per day. The monthly fuel consumption averages 150 cords of wood, costing $4 per cord. Running altogether eight months in 1884, the works turned out 652,110 pounds of precipitate, averaging 81.6 per cent. of copper, equal to 532,121 tons fine. The bulk of it, about 35 tons per month, is disposed of on the Pacific coast for conversion into bluestone for the silver mills, the balance being shipped to eastern refining works.

A small quantity of cement copper has also been made at the Campo Seco, Quail Hill, and Napoleon mines, and at the Stella mine, Silver creek, Alpine county, which belongs to the Isabelle Gold and Silver Mining Company, limited, of London, England, and which produces at the same time some silver and gold.

Colorado.—The bulk of the copper produced in Colorado is obtained as a by-product in smelting, notably the argentiferous and auriferous ores of Gilpin and Clear Creek counties and the San Juan region, the copper acting as a carrier of the precious metals. The bulk of the ore is treated at the works of the Boston and Colorado Smelting Company. At the same time ores from other States and Territories are treated. Care has been taken to credit the quantities thus apparently originating in Colorado to its true source. A good deal of the product is exported, and the bulk of the balance is sold to manufacturers of bluestone, so that the amount of ingot copper refined at American works and destined for the American market is comparatively small. As the copper still contains considerable quantities of silver and gold, and is, besides, contaminated with tellurium, arsenic, antimony, and bismuth, it is not likely to be diverted from its present channels, unless the metallurgical methods undergo some change.

Considerable ore has been taken out of the Sedalia mine, at Salida, in the course of development work, which it is reported carries about 13 per cent. of copper. A small quantity was smelted during the year at Cañon City, where the Rocky Mountain Mine Developing Company has made a short campaign.

Utah.—The principal mine (the Crismon Mammoth) has been closed by litigation, and now only small quantities of ore are shipped to Colorado. A small smelter has been erected at Saint George during the year 1884.

Wyoming.—The copper resources of Wyoming have been claimed to be very extensive, a very large area having been prospected with encouraging results. The leading producer has been the Wyoming Copper Company, which has smelted in a 40-ton water jacket about 4,200 tons of carbonates and oxide from the Sunrise mines. This ore, which has averaged about 15 per cent., has iron oxide as the chief gangue, so that it is self-fluxing. The copper, which at one time reached the New York market in considerable quantity, was pronounced to be of good grade. Smelting was stopped after four months' run on account of the drop in the price of copper, the absence of railroad facilities making it impossible to meet the market. Being a hundred miles from the railroad, the coke cost, laid down at furnace, about $37 per ton, and the expense of hauling product was correspondingly large. Even with so heavy an expenditure for fuel the total cost per pound of copper at the smelter is put at 8½ cents, equivalent to 11½ cents marketed as ingot. The Sioux City and Pacific Railroad is now building toward the region in which the copper district is located, and, with proper facilities, a lower grade of ore can be worked at a lower cost. The district is, therefore, one that holds out a promise for the future.

Nevada.—The production has been limited, and the shipments of ore from Battle Mountain to England have ceased early in 1884.

Idaho.—Aside from small quantities of copper contained in gold and silver ores treated at such works as the Boston and Colorado Smelting Company, at Argo, Idaho has thus far produced no copper. Toward the close of November a smelting furnace was started in connection with copper mines at Houston, Big Lost river.

Missouri.—At the Genevieve copper mines continued work has been done during the past two years. On January 1, 1884, the Harris Copper Company leased the works to Messrs. Potter & Nicholson, who have worked only ore coming from the Cornwall mines, no refining of bars having been done by them. Work has stopped, and the establishment is for sale.

Texas.—Some attention has been given during 1883 and 1884 to the copper deposits of Texas. Mr. W. H. Streeruwitz, M. E., of Houston, states that those of Llano county are best known and best defined by outcrops. The copper minerals are found there as impregnations in granite and as veins with quartz gangue in granite, and are generally carbonates, the result of surface decomposition, and at greater depth are sulphurets and gray copper generally carrying gold and silver. Contact deposits between crystalline slates and granite are also known. The copper outcrops are more clearly defined north of the Llano river on the headwaters of Pecan, Babyhead, Little Llano, and San Fernando creeks. There are also copper outcrops in the northwestern corner of Llano county, running into Mason county, though they appear to carry only smaller quantities of the precious metals. Some of the Llano county veins may be traced over to San Saba county, and traces of old Spanish diggings show that at least attempts at working were made in spite of hostile Indians. Mr. Streeruwitz judges from samples said to have come from that quarter that pyritic ores prevail. He expresses the opinion that copper may be found in parts of the whole granite and crystalline slate belt which extends through parts of the counties of Burnet, Blanco, San Saba, Mason, Gillespie, and Menard.

A second group of copper deposits has been discovered nearly due north of the former, in the district embraced by Stonewall, Haskell, Baylor, Archer, and Wichita counties, south of the Indian Territory. Mr. E. T. Dumblé, chemist and geologist, of Houston, pronounces it Permian. Mr. Streeruwitz states that the ore, carbonate, and pseudomorphous copper glance is found loosely distributed in a bluish gray clay. He adds that the ores seem to be washed down from the Wichita range. Large masses, weighing as much as 2 tons, have been found, but no vein has as yet been exposed.

The third field is in southwestern Texas, on the eastern slope of the Chinate mountains, near Fort Davis, and in the ranges between the latter point and New Mexico.

Very little systematic and well directed prospecting has as yet been done in Texas, and all but the few operations in charge of competent persons have failed disastrously. There are now, however, under way two or three well conducted enterprises, so that it is possible that at no distant time Texas may begin to figure as one of the copper-producing States. The most prominent is the Great Belt Copper Company, a New York organization, of which General G. B. McClellan is president. A force of thirty men is now engaged in doing preliminary work, and smelting furnaces have been ordered.

Dakota.—Thus far no copper has been produced in Dakota. The Gray Eagle Copper Mining and Smelting Company, however, is at work completing its smelter, which it is expected will blow in in May.

Vermont.—The Ely mines, at one time heavy and steady producers, have turned out a little copper in 1883, but since the middle of that year have been closed down by litigation. The Elizabeth mines of South Strafford have been smelting, however, until recently, when all but mining and roasting was suspended. Only a part of the product reached the market.

IMPORTS.

The imports of fine copper contained in ores, and regulus and black copper, and of ingot copper, old copper, plates not rolled, rolled plates, sheathing metal, and manufactures not otherwise specified, and of brass, are given in the following tables:

Fine copper contained in ores, and regulus and black copper imported and entered for consumption in the United States, 1867 *to* 1884 *inclusive.*

Fiscal years ending June 30—	Fine copper contained in ores.		Regulus and black copper. (a)		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		
1867	....	$936,271	....	....	$936,271
1868	3,406,994	197,203	....	....	197,203
1869	24,960,604	448,467	....	....	448,487
1870	1,036,875	134,736	....	....	134,736
1871	411,315	42,458	490	$60	42,518
1872	584,678	69,017	4,247	1,083	70,100
1873	762,066	80,132	1,444,239	279,631	359,763
1874	666,266	70,633	38,800	5,397	76,030
1875	1,337,104	161,903	12,518	2,076	163,979
1876	538,972	68,922	8,584	1,613	70,535
1877	76,637	9,756	1,874	260	10,016
1878	87,030	11,765	....	....	11,765
1879	51,950	6,190	....	....	6,190
1880	1,165,283	173,712	2,301,394	337,163	510,875
1881	1,077,217	124,477	402,640	51,633	176,110
1882	1,478,169	147,416	224,052	30,013	177,429
1883	1,115,386	112,849	....	....	112,849
1884	2,304,070	219,957	2,036	204	220,161

a Not enumerated until 1871.

Copper imported and entered for consumption in the United States, 1867 *to* 1884 *inclusive.*

Fiscal years ending June 30—	Bars, ingots, and pigs.		Old, fit only for remanufacture.		Old, taken from bottoms of American ships abroad. (b)		Plates not rolled.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
1867	1,635,953	$287,831	569,732	$81,930	....	....	....	....
1868	61,394	6,935	318,705	42,652	....	....	....	....
1869	13,212	2,143	290,780	34,820	....	....	....	....
1870	5,157	418	255,386	31,931	....	....	....	....
1871	3,316	491	369,634	45,672	....	....	430	$129
1872	2,638,569	578,965	1,144,142	178,536	....	....	148,193	33,770
1873	9,697,668	1,984,122	1,413,040	255,711	32,307	$4,913	550,431	97,688
1874	713,986	134,336	733,326	137,087	9,500	930	....	....
1875	58,475	10,741	396,320	55,164	11,636	1,134	8	4
1876	5,221	788	239,967	35,545	10,304	1,081	5,467	600
1877	230	30	210,448	28,608	41,482	5,136	....	....
1878	1	....	196,749	25,565	....	6,004	....	....
1879	2,515	352	112,643	11,997	11,000	1,107	27,874	4,496
1880	1,342,108	208,121	695,255	91,244	....	....	120	11
1881	219,882	36,168	541,074	63,383	14,680	1,504	20	3
1882	6,390	836	506,901	59,625	16,075	1,629	....	....
1883	....	....	330,495	36,166	9,415	668	....	....
1884	c 542	107	149,701	12,099	....	534	....	....

b Not enumerated until 1873.

c Includes "plates not rolled."

Copper imported and entered for consumption in the United States, &c.—Continued.

Fiscal years ending June 30—	Plates rolled; sheets, pipes, etc.		Sheathing metal, in part copper. (a)		Manufactures not otherwise specified.	Total value.
	Quantity.	Value.	Quantity.	Value.	Value.	
	Pounds.		*Pounds.*			
1867	....	$1,101	229,880	$37,717	$15,998	$424,585
1868	....	1	101,468	18,852	21,492	59,955
1869	....	89	48,669	6,592	43,212	98,800
1870	....	2,080	....	....	485,230	519,006
1871	....	7,487	....	....	668,804	722,073
1872	....	18,895	....	....	1,007,744	1,017,910
1873	....	4,514	....	....	860,281	3,216,430
1874	....	27	282,406	50,174	125,706	448,232
1875	....	617	136,055	22,080	26,573	127,272
1876	....	336	18,014	2,903	39,806	71,949
1877	....	203	110	23	41,763	75,761
1878	....	1,201	667	55	35,473	88,818
1879	....	738	300	20	50,277	58,035
1880	....	4,134	6,044	693	120,329	433,538
1881	....	82	39,520	4,669	284,506	990,218
1882	5,855	1,851	....	....	77,727	141,378
1883	2,842	379	8,791	1,047	40,343	74,001
1884	6,529	2,330	19,637	926	55,274	71,290

a Does not include copper sheathing in 1867, 1868, and 1869.

Brass imported and entered for consumption in the United States, 1867 *to* 1884 *inclusive.*

Fiscal years ending June 30—	Bars and pigs.		Old, fit only for remanufacture.		Not otherwise provided for.	Total value.
	Quantity.	Value.	Quantity.	Value.	Value.	
	Pounds.		*Pounds.*			
1867	....	$3,099	....	$26,468	$170,873	$200,440
1868	31,104	2,071	120,913	11,698	181,114	194,883
1869	32,170	2,457	131,640	10,838	198,310	211,605
1870	54,106	3,791	98,825	6,918	49,845	60,554
1871	28,453	2,803	438,085	37,922	13,659	54,384
1872	17,963	1,754	829,964	73,008	23,738	98,500
1873	56,656	7,147	699,478	71,494	114,767	193,408
1874	253	19	682,151	64,848	350,266	415,133
1875	370,273	38,867	124,285	12,780	273,878	325,525
1876	....	....	618,191	54,771	232,870	287,641
1877	....	....	689,633	59,402	207,642	267,044
1878	....	....	713,171	57,551	205,209	262,760
1879	950	49	485,854	32,278	232,030	264,357
1880	....	....	958,590	75,093	339,131	414,224
1881	85,370	11,203	1,615,403	151,541	331,505	494,249
1882	30,769	3,168	2,904,142	234,491	460,477	698,136
1883	6,280	559	1,015,345	84,786	491,321	576,666
1884	1,011	445	568,923	40,766	429,224	470,435

EXPORTS.

The wide fluctuations in the quantities of copper, copper ore, and manufactured copper exported for a series of years are exhibited in the following tables:

Copper and copper ore of domestic production exported from the United States, 1864 to 1884 inclusive.

[Cwts. are long hundredweights of 112 pounds.]

Fiscal years ending June 30—	Ore.		Pigs, bars, sheets, and old.		Value of manufactured.	Total value.
	Quantity.	Value.	Quantity.	Value.		
	Cwts.		*Pounds.*			
1864	109,981	$101,298	102,881	$43,229	$308,043	$452,570
1865	225,197	553,124	1,572,382	709,106	282,040	1,544,270
1866	215,090	792,450	123,444	23,553	110,208	926,211
1867	57,731	317,791	a 4,637,867	303,048	171,062	791,901
1868	92,613	442,921	1,250,636	327,287	162,201	932,409
1869	121,418	237,434	1,134,380	233,983	121,342	592,759
1870	a 19,106	537,505	3,214,450	385,815	118,926	1,042,246
1871	a 54,445	727,213	561,650	133,020	55,198	915,431
1872	35,564	101,752	307,868	64,844	121,139	287,735
1873	45,252	170,365	38,956	10,423	78,288	259,076
1874	13,326	110,450	503,199	123,457	233,301	467,208
1875	a 51,305	729,578	5,123,470	1,042,526	43,152	1,815,256
1876	15,304	84,471	14,304,199	3,098,395	343,544	3,526,410
1877	21,432	109,451	13,461,563	2,718,213	195,730	3,023,394
1878	22,947	169,020	11,297,576	2,102,455	217,446	2,488,921
1879	23,670	102,153	17,299,739	2,751,153	79,990	2,933,296
1880	21,628	55,763	4,206,258	667,242	126,213	849,218
1881	9,936	51,499	4,805,407	786,860	32,636	870,995
1882	25,990	89,515	3,340,531	565,295	93,646	748,456
1883	112,922	943,771	8,221,363	1,293,947	110,286	2,348,004
1884	386,140	2,930,895	17,044,700	2,527,829	137,125	5,595,850

a Evidently errors in quantities.

Value of copper, brass, and manufactured copper exported from the United States to 1863, inclusive.

Fiscal years ending September 30 until 1842, and June 30 since.	Value.	Fiscal years ending September 30 until 1842, and June 30 since.	Value.
1791	$403	1833	$203,880
1803	6,253	1834	108,273
1804	8,654	1835	69,791
1805	12,977	1836	72,901
1806	25,340	1837	91,724
1807	12,742	1838	81,363
1808	4,031	1839	81,234
1809	3,095	1840	86,904
1810	17,436	1841	72,932
1811	9,282	1842	97,021
1812	2,644	1843 (nine months)	70,204
1813	....	1844	91,448
1814	....	1845	94,736
1815	306	1846	62,088
1816	16,158	1847	64,980
1817	8,705	1848	61,468
1818	33,870	1849	66,203
1819	12,721	1850	105,060
1820	16,547	1851	91,871
1821	26,694	1852	108,030
1822	36,974	1853	106,205
1823	16,768	1854	91,964
1824	26,961	1855	690,766
1825	30,472	1856	594,846
1826	60,098	1857	607,604
1827	52,341	1858	1,985,223
1828	60,453	1859	1,046,246
1829	129,647	1860	1,664,122
1830	86,801	1861	2,375,020
1831	55,755	1862	1,098,546
1832	105,774	1863	1,026,038

Value of brass, and manufactures of, exported from the United States, 1867 to 1884 inclusive.

Fiscal years ending June 30—	Value.	Fiscal years ending June 30—	Value.
1867	$12,984	1876	$256,974
1868	16,841	1877	397,017
1869	40,069	1878	369,451
1870	109,897	1879	290,871
1871	210,816	1880	129,469
1872	229,456	1881	216,657
1873	494,575	1882	322,439
1874	563,531	1883	267,247
1875	1,000,039	1884	301,014

Exports of copper and copper ore of domestic production and of domestic manufactures of copper in the calendar years (ending December 31) 1883 and 1884.

Exports.	1883.		1884.	
	Quantity.	Value.	Quantity.	Value.
Copper ore, long tons	12,253	$1,971,581	33,672	$4,366,910
Ingots, bars, and old copper, pounds	18,206,187	2,784,816	30,321,295	3,872,436
Sheets, pounds			53,964	16,323
All manufactures of copper		126,268		112,505
Total		4,882,665		8,368,174

The exports of copper during the calendar year 1884 were 30,321,295 pounds, in the form of ingots, bars, and old copper. The bars are almost exclusively Arizona product, being the black or blister copper as made at the furnaces. From a comparison of the total Arizona output and of the quantity of copper shipped to American refining works, and the small amounts taken by consumers direct, it may be estimated that 3,700,000 pounds were exported in that form. The refiners and the Boston and Colorado Works exported 4,600,000 pounds, coming, of course, from a variety of sources. The Lake companies sent out 18,000,000 pounds between May, 1884, and January, 1885, thus leaving about 4,000,000 pounds as the export of second hands. The copper contents of the 33,672 tons of ore and matte exported are estimated to have been 28,000,000 pounds, almost all of it Montana product, thus making the shipments to foreign countries in all 58,300,000 pounds. The quantity apparently available for home consumption is therefore 83,300,000 pounds, from which must be deducted the amount of Colorado, California, and desilverizers' product used for making bluestone. It may be fairly stated, then, that our home consumption was called upon to deal with about 80,000,000 pounds of copper. This it has undoubtedly done, since the supply at the end of the year was by no means excessive. It is certainly a highly encouraging feature that our manufacturers took so large a quantity of metal in spite of the dull times. While the demand for machinery, brass castings, and alloys was probably below the average of former years, the quantity consumed, notably for electrical purposes and for domestic utensils and ornaments, was certainly very much larger. A very encouraging point has been the growing favor of hard-drawn copper wire for telegraph lines. One telegraph company, judging from the mileage of this class of wire and its average weight per mile, must have alone used fully 1,000,000 pounds. Hard-drawn copper wire is very highly spoken of by electricians as a material for the transmission of messages by modern methods, and if the great promises of the trials made thus far are borne out by long continued experience, a demand will be created which will be highly beneficial to the metal. There has been a good deal of agitation, largely misdirected, looking to the wider introduction of copper as a material for roofing, water service, etc. There is some future for the use of the metal in this direction if low prices continue, but it must necessarily be a matter of slow growth, not likely to affect consumption very materially in the next few years.

The export of manufactured goods has as yet made very little headway in spite of the fact that our manufacturers now have a very cheap raw material, and their works are splendidly equipped to produce cheaply a large variety of very tastefully made goods. There can be no question that this is a field worthy of cultivation and in which American manufacturers can develop a large and growing outlet.

THE COPPER MARKETS.

The following table summarizes the highest and lowest prices obtained for Lake copper monthly in the New York market from 1860 to 1884, both inclusive:

Highest and lowest prices of Lake Superior ingot copper, by months, from 1860 *to* 1884.

[Cents per pound.]

Years.	January.		February.		March.		April.		May.		June.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
1860	24	23½	24	23½	23¾	23	23½	23	23½	22¾	23¼	21¾
1861	20	19	19¼	19	19¾	19¼	19¼	19	19¾	19¼	19	18
1862	28	27	28	25	25	23	23	21½	21¾	20¾	23	20¾
1863	35	31	37	35	37	31	31	30	30¾	30	30¼	30
1864	41½	39	42	41½	42½	41½	44	42½	44	43	49	44
1865	50½	46	46	44	44½	34	35	34	34	30	30½	29½
1866	42	35	38	35½	35½	29½	30	30½	31	29	32	31
1867	29¼	27	27½	27¼	27½	24	24¼	23¼	24¼	24	24½	24
1868	23¼	21½	24	22½	24	23½	24½	23¾	24¼	24	24	23½
1869	26¼	22½	27	26	26¾	24	24	23½	24½	23¾	23¾	22
1870	22	21½	21½	20½	20½	19	19½	19½	19½	19	20¾	19
1871	22¾	22	22¾	21½	22	21½	21½	21½	21½	21¾	22	21½
1872	28¼	27¾	28¾	29½	30½	29¾	44	30½	42	36	34½	32
1873	35	32¼	35	34	35	34½	34½	32¾	33½	32	31¼	28¾
1874	25	24½	25	24¼	24¾	24¼	25	24¾	25	24¼	24¾	24½
1875	22¼	21½	22¼	21¾	21½	21½	21½	21¼	23¼	22¾	23	23
1876	20¼	20	22¼	22¼	22¾	22	22¾	22	22¼	21	21	19½
1877	19½	19	20½	19¼	19¼	19	19¾	19¾	19¼	19	19¾	19
1878	17½	17¼	17½	17½	17¾	16½	17	16½	16½	16½	16¾	16¼
1879	16	15½	15½	15½	15½	15½	16	15¼	16½	16	16½	16¾
1880	25	21½	24½	24	24	22½	22½	21	21	18	18½	17½
1881	18¾	18½	19½	19¼	19½	19	19	18¾	18½	18¼	17¼	16¾
1882	20¾	20¼	20	19	19¾	18½	18¾	17¾	18¾	18	16¾	18
1883	18¾	18	17¾	17½	17¾	17½	16¾	15¾	16	15¾	16¾	15
1884	15	14½	15	14½	15	14½	15	14¾	14½	14½	14¼	14

Highest and lowest prices of Lake Superior ingot copper, &c.—Continued.

Years.	July.		August.		September.		October.		November.		December.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
1860	21½	21¾	21½	21¾	22	21½	22	21½	21½	20½	20½	19½
1861	18	17¾	19	17¾	20½	19	20½	20	22½	20½	27	22½
1862	24½	22½	24½	24	27	24½	32½	27	32½	30½	31½	30½
1863	33	29	31	29	32½	31	34½	32½	38½	34½	34½	38½
1864	55	49	52½	50	52½	47½	48	47	49	47	50	46½
1865	30½	28	32	30½	32½	31½	33	32½	45½	33	45½	30½
1866	32¾	31	31	30	31½	30¾	31	30¾	30½	29¾	30	26½
1867	26	24	26½	25¾	27½	25¾	26¾	22¾	23	22¾	23	21½
1868	24½	23½	24½	24	24	23½	24	23	24	22½	24½	22
1869	22½	21½	23½	21½	23	22	22½	23	22½	22	22	21½
1870	20¾	20¾	21¾	20¾	21½	20½	21¾	21½	23½	21½	22½	22½
1871	22½	21¾	22	22¾	22¾	22½	22¾	22½	24½	23½	27	24½
1872	34	33	35	32½	35½	33	34½	31½	32½	30½	32½	30½
1873	29	26½	27½	27	27	25½	25½	24	24	21	25	23
1874	24½	25	21	19	21½	21	22½	21½	23½	22½	23½	23½
1875	23	22¾	23½	23	22½	20½	22½	23	22½	23	23½	21½
1876	20	19¾	19¾	18¾	21	18¾	21½	20½	20½	20	20	19½
1877	19¾	19	19	17¾	18½	17¾	18	17¾	17¾	17½	17¾	17¼
1878	16½	16	16	16	16¾	16	16	15½	15¾	16½	16	15½
1879	16¾	16	16¾	16	17	16½	21½	16	21¾	21	21½	21
1880	19¼	18½	19¾	19	18¾	18¾	18¾	18¾	18¾	18¾	19½	18½
1881	16¾	16	16¾	16⅛	16¾	16¾	16¾	16	19	18¾	20½	19½
1882	18½	16¾	18½	16½	18¾	18	16¾	16	16½	16	18	17½
1883	15⅝	15	15	15	15½	15¼	15½	15½	15	14½	15	14½
1884	14⅝	13¾	14	13⅝	13½	13	13½	12¾	13	12¾	12½	11

1883.—During 1883 the prices of Lake Superior copper and of good ordinary Western brands varied as follows:

Prices of copper in 1883.

Months.	Lake copper in New York.		Good ordinary Western in New York.		Average monthly price of Chili bars in London.		
	Highest.	Lowest.	Highest.	Lowest.			
	Per pound.	*Per pound.*	*Per pound.*	*Per pound.*	*Per long ton.*		
January	$0 18½	$0 18	$0 17	$0 16	£66	5	6
February	17¾	17½	16½	15¾	65	8	9
March	17¾	a 17¼	15¾	15½	65	13	8
April	18	16½	15	14¼	65	11	10
May	16	15½	15	14½	62	9	2
June	16¼	b 15	14½	14	64	0	3
July	15⅝	15	14¼	14	63	17	0
August	15	15	14¼	14	63	16	0
September	15½	15¼	14¼	14¼	63	12	3
October	15½	15¼	14¼	14¼	61	17	6
November	15	b 14¾	14¼	14	60	8	6
December	15	14⅝	14¼	14	58	6	6

a For export, 16 cents. b For home consumption, 15 cents.

In the early part of January manufacturers contracted with Lake companies for the purchase of ten to eleven million pounds of copper, approximately two to three months' demand, at 18 cents. The result was that sellers of other brands began to show much anxiety in disposing of their product, and a decline was precipitated, which more and more widened the gap between the quotations of Lake and of other brands. This brought out from week to week small lots of Lake to be resold by those manufacturers who desired to realize a profit by using Western copper. Under the pressure thus brought to bear, Lake copper slowly receded, and in turn forced down the price of competing brands. This decline was rendered more rapid still by the efforts of sellers of unknown brands to obtain a foothold, and by the throwing upon the market of Western copper by bankers who had made advances upon it. The eagerness of holders to place their metal naturally increased the reluctance of buyers, who were confirmed in their position by the fact that the demand for manufactured goods was slack and had been made worse by the competition for trade by makers, of whom each believed himself to be capable of outbidding others because of low purchases of raw material. The demoralization in the latter spread to the manufacturing trade, which only aggravated the evil. In the middle of March the Lake companies sold about 7,000,000 pounds of copper for export, and when this movement did not seem to check the decline or shake the position of buyers, they suddenly, in the beginning of April, began to be free sellers at 16 cents. A considerable quantity of copper was placed, but there was not, it appears, a pool of sellers negotiating with the principal buyers. The first effect of this sudden turn was to force a few small holders to realize at lower figures. Since then Lake was pretty firmly held at 15⅞ cents, though it slightly recovered, the quantities offered being slight in April and May. In June the Lake companies again came forward, contracting for the delivery of 20,000,000 pounds to consumers at 15 cents. Meanwhile other brands dropped off, particularly those not having a recognized standing or marketed under special circumstances. The quotations given above are for fair brands; they are higher, in some cases as much as one-quarter to three-eighths of a cent, than the figures which have formed the basis of actual transactions. They are lower, on the other hand, than the prices readily obtained for certain special brands made of black copper produced from the pure oxidized ores, notably of Arizona, and which range only one-half of a cent lower than Lake copper. It is striking that the differences should be so great, being in some cases as much as 1½ cents per pound. There can be no doubt that, intrinsically, copper refined carefully and having no grave quantities of impurities is worth more than the difference in quotations would indicate. Chili bars containing only 96 per cent. of copper have been occasionally sold in this market during the past ten years, and generally the difference was not more than 1½ cents per pound.

July passed by quietly, though without any evidences of weakness, a surplus of outside brands being marketed abroad, so that early in August the latter developed more strength. There were also during that month some export sales of Lake copper at prices equivalent to those ruling in this market, and in spite of a pretty steady decline abroad there was a better feeling generally throughout September. In October, while waiting for developments concerning the coming contracts between the Lake companies and the consumers, some of the latter were forced to come into the market for small lots, which accordingly realized slightly higher prices. In the middle of the month it was given out that the old contracts at 15 cents had been extended to cover the balance of the year, and somewhat later it was announced that the arrangement in reality covered the period to April, 1884, involving the sale of, roughly, 20,000,000 pounds. It was understood that much of this copper was to be delivered at buyers' factory, a step probably taken to make the exchange of other brands for Lake on a falling market more difficult.

The last two months of the year were as usual without events of any significance. There was very little copper pressing on the market, and on the other hand buyers were few and their purchases unimportant. Very little, if any, Lake copper was thrown upon the market by manufacturers.

1884.—During this year the fluctuations in the prices of Lake copper and of good Western brands were as follows:

Prices of copper in 1884.

Months.	Lake copper in New York.		Good ordinary Western brands in New York.		Average monthly price of Chili bars in London.	Average monthly price of copper ore in Liverpool, 25 per cent.	Average monthly price of precipitate in Liverpool.
	Highest.	Lowest.	Highest.	Lowest.			
	Per lb.	*Per lb.*	*Per lb.*	*Per lb.*	*Long ton.*	*Per unit.*	*Per unit.*
January	$0 15	$0 14[illegible]	$0 14[illegible]	$0 13[illegible]	£58 0 6	£0 11 3	£0 11 10
February	15	14[illegible]	14[illegible]	13[illegible]	56 1 3	11 0	11 10[illegible]
March	15	*a* 14[illegible]	13[illegible]	13[illegible]	54 15 6	10 10	11 4
April	15	*b* 14[illegible]	13[illegible]	13[illegible]	56 3 10	10 9	11 3[illegible]
May	14[illegible]	14[illegible]	13[illegible]	13[illegible]	55 10 0	11 11	11 8[illegible]
June	14[illegible]	14	13[illegible]	12[illegible]	54 18 0	10 6[illegible]	11 3[illegible]
July	14[illegible]	13[illegible]	13	12[illegible]	54 7 3	10 9[illegible]	10 11[illegible]
August	14	13[illegible]	12[illegible]	12[illegible]	54 9 6	10 1	10 10[illegible]
September	13[illegible]	*c* 13	12[illegible]	12	54 4 5	10 2	10 9[illegible]
October	13[illegible]	12[illegible]	12	11[illegible]	53 15 7	10 1[illegible]	10 9[illegible]
November	13	12[illegible]	11[illegible]	11[illegible]	52 5 0	9 9	10 5[illegible]
December	12[illegible]	11	11[illegible]	10[illegible]	48 18 3	9 1[illegible]	9 11[illegible]

a For export, 13 cents. *b* For home consumption, 14 cents. *c* For home consumption, 13 cents.

Since the English quotations have become of such direct importance to American copper miners, the following table, showing a comparison of values in 1884 with former years, is of interest:

Average values in England.

Years.	Chili bars.	Ore, 25 per cent.	Precipitate.
	Long ton.	*Per unit.*	*Per unit.*
1880	£62 10 0	£0 12 9	£0 13 11
1881	61 10 0	12 6	13 8[illegible]
1882	66 17 0	13 6[illegible]	13 10[illegible]
1883	63 5 10	12 4[illegible]	12 10[illegible]
1884	54 9 1	10 8[illegible]	11 1

With a view to illustrating the difference in quotations between ordinary Chili bars, the speculative article, and one of the best brands, ranking with Lake copper, regularly quoted in England, the prices at the end of each month during the year 1884 are given:

Comparison of prices in England.

Dates.	Chili bars.	Wallaroo.	Difference.
December 31, 1883	£58	£67	£9
January 31, 1884	56¾	65¼	8½
February 29, 1884	55¾	64	8¼
March 31, 1884	54	62½	8½
April 30, 1884	56⅛	64½	8⅜
May 31, 1884	56	64	8
June 30, 1884	54⅞	62	7⅛
July 31, 1884	55	62	7
August 31, 1884	54	61	7
September 30, 1884	54	61	7
October 31, 1884	52¾	61	8¼
November 30, 1884	50¾	59	8¼
December 31, 1884	47¾	56¼	8½

The year opened quietly, with little pressure to sell on the one hand, and comparatively very little inquiry. The Lake companies declined fair foreign orders, and January closed a shade firmer. February was exceedingly dull, nothing whatever occurring to change values or to indicate any early movement upward or downward. Refiners of other material suffered to some extent from the usual winter curtailment of the supply of black copper, ore, and matte, and showed less tendency to anticipate consumers' wants or force metal abroad. When, however, in March it became known that the Lake companies had contracted abroad for the delivery of 7,500 tons at 13 cents, the sellers of other brands began to show more anxiety, and the usual tactics of placing as much copper as possible before the coming Lake sale were followed, the effect being a gradual decline in the price of these brands. This again reflected back upon Lake copper, which began to weaken, and forced the companies to name 14 cents as the basis of their contracts with consumers, involving about 12,000,000 pounds for delivery during the summer. In spite of the financial troubles of May that month passed quietly, the only feature being the continued weakening of outside brands. In June it seemed for a time that the floods of the Colorado and Rio Grande rivers would, by cutting off the coke supply to some of the Arizona producers, diminish the output of that Territory, but the damages to the railroads were promptly repaired and had little effect. July was quiet, and there was comparatively little selling of Lake copper on the part of manufacturers who were replacing it by cheaper Western brands. The latter showed considerable weakness during August, a month during which the usual maneuvering between the companies and the consumers was going on. Early in September the contracts were closed on the basis of 13 cents, the quantity involved being about 10,000,000 pounds. The other brands promptly followed the drop; but the sellers of this class of metal sought relief by marketing as much as possible abroad, the export sales of Arizona refined and bar aggregating fully 1,500 tons. Contracts were also closed for 9,000 tons of Montana ore in England. The Lake companies meanwhile declined export orders at 12½ cents, but in the following month they were selling at 12¼ and 12⅜.

In sympathy with the decline abroad the market here showed an unbroken tendency downward and the contracting of heavy quantities of Montana matte in England—the Anaconda, for instance, selling its 1885 product of about 7,500 tons matte based on quotations of best selected—did not tend to mend figures. The Calumet and Hecla fire in October had no effect upon the market, and in the beginning of December the Lake companies met the decline by selling to consumers at 12 cents. They were at the same time heavy sellers in Europe, contracting to deliver 7,500 tons, the copper being taken evidently on speculation by a large banking concern, on the basis of Chili bars, which began to show a heavy decline early in December. These sales were made allowing only an advance of £4 per ton for Lake over Chili bars, which the purchasers are marketing at about £7 over Chili bar quotations. Toward the end of the month it was announced that the Lake companies had made a contract for the first five months of 1885 with domestic consumers, the quantity involved being about 2,000,000 pounds per month. The price to be paid is based on the average quotation of Chili bars for the preceding month for the dates ranging between the 10th and the 25th. The lowest price is to be 10½ cents, when Chili bars have averaged £48 or under, the price to advance one-tenth of 1 cent for every 10s., increased average until £53 or over is reached, when the maximum price is to be 11½ cents. It is understood that under this arrangement the January price was fixed at 10.60 cents. The sale, it is stated, is coupled with the condition that the purchasers are not to use any other brands of copper. It would appear, therefore, that every effort is being made to secure to the pool the customers it holds, the sales for export being invariably made with the proviso that none of the copper is to be returned to this country, while domestic buyers are enjoined from placing copper once bought upon the open market. The latter step was evidently taken to protect the market against resales by manufacturers who, especially during 1882 and 1883, frequently replaced Lake bought by other cheaper brands of Western copper, throwing the Lake upon the market.

A great event during the year was the withdrawal of the Quincy Mining Company from the pool, and the appeal on the part of the other members of it to the courts for an injunction, which was denied. From the papers in the suit and from published statements growing out of it considerable light was thrown upon the character of the pool. It appears that on the 14th of February an agreement was made, substantially, so far as is known, modeled after similar earlier covenants, designating the Calumet and Hecla Company as selling agent of the combined product of the Calumet and Hecla, Quincy, Atlantic, Central, Allouez, Franklin, Pewabic, Huron, Conglomerate, and Copper Falls mines.

The only large company not a member of the pool was the Osceola, which, however, sold to Waterbury manufacturers on the basis of the pool sales. The agreement was entered into till the 1st of January, 1885, but subsequently, on August 20, was extended to March 31, 1886. One clause of the agreement, not generally known, was that the Calumet and Hecla Company had the right to temporarily withhold from apportionment 10 per cent. of the pool sales as a fund to be used at the discretion of the Calumet and Hecla Company for the purpose of relieving any of the small companies from any strain caused by the accumulation of copper on their hands or for the purchase of Lake copper in the market.

In reply to an inquiry from the Quincy Company the Calumet and Hecla Company informed the Quincy that 2,000 tons of special size cakes had been sold for export in October, November, and December, but that owing to inability to deliver the October portion the dates of delivery were changed to November, December, and January, 1885, the price to be paid to be the average price of Chili bars in each of the months named, with £4 added.

It is reported that the November settlement showed that for its share of the export sale of that month it received 11⅝ cents per pound of copper. The Quincy accepted offers of 12 cents per pound for 1,200 tons for export, and it was then that proceedings against it were begun. To-day, therefore, two large companies, the Quincy and the Osceola, have withdrawn from the combination, which, so far as its control of the domestic market is concerned, has outlived its usefulness, chiefly on account of the competition of the Western mines, and has since been entirely abandoned.

The prices realized for the copper produced vary somewhat. The following table, compiled from the reports of the different mines to the shareholders, exhibit these fluctuations and furnish a fair basis to estimate the average price obtained during the year:

Prices realized for Lake Superior copper in 1883.

Mines.	Sales.	Average price.
	Pounds.	*Cts. per lb.*
Allouez	1,751,877	15.13
Franklin	3,418,456	15.06
Atlantic	2,385,985	15.00
Pewabic	1,239,740	15.91
Central	1,125,910	15.60
Huron	647,767	15.60

THE PRINCIPAL FOREIGN PRODUCERS.

Since American producers have begun to assume the role of more than occasional sellers in foreign markets and have come into direct competition with the mines of almost every quarter of the globe, the question constantly arises how far are our foreign rivals capable of holding their ground, what point must be reached in the decline before an enforced restriction of output is reached, and to what extent our own mines will share in that cessation of work. We know that the English mines will practically cease to exert any influence, that the Australian, Canadian, and Venezuelan producers must go to the wall should prices for ore and regulus remain below 10s. per unit for any length of time; on the other hand that the great pyrites mines of Spain and Portugal can live, that the Cape of Good Hope product will continue, that the Mansfeld district in Germany will contrive to make ends meet, but we have little positive information, unfortunately, concerning the heaviest copper shipping country, Chili. In the absence of any precise knowledge concerning the cost of production in that country, or of the capacity of the rich owners of the leading mines to bear up under heavy losses, it is only possible to repeat the general impression in well informed quarters that prices below £50 in London press very heavily upon the copper industry of Chili. On some of the points at issue data will be found in the following review of the development of the copper industry in the leading producing countries.

Aside from the interest which attaches to the affairs of producers in foreign countries, since we have become their direct and most feared competitors, the markets of Great Britain, reflecting as they do the demand and supply of the world, have attained a new and direct significance because the prices paid for nearly one-half of the make of our country are based upon the daily quotations of Chili bars or of best selected. Every movement, every fluctuation in the world's markets is immediately felt by American producers, directly or indirectly.

Messrs. Henry Merton & Co. have compiled the following table of the copper production of the world, and have since its publication kindly completed some of the estimates when later returns were available. Some of the data have been changed and corrected by this office from information directly received from various quarters. The copper is in all cases credited to the source where it originated. Thus the contents of the pyrites shipped from Spain are included in the figures given for that country. The table as it stands reflects the results of the closest scrutiny and may be accepted as the most complete and accurate now available.

The copper production of the world, 1879 to 1883 inclusive.

Countries.	1883.	1882.	1881.	1880.	1879.
EUROPE.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Great Britain	2,030	3,464	3,875	3,662	3,462
Spain and Portugal:					
Rio Tinto	20,472	17,389	16,008	16,215	12,701
Tharsis	9,800	9,000	10,209	9,151	11,324
Mason & Barry	8,000	8,000	8,170	6,503	4,692
Sevilla	2,028	1,835	1,340	1,705	1,380
Portuguese	2,357	1,700	1,410	1,000	770
Poderosa	1,000	800	800	800	800
Germany:					
Mansfeld	12,604	11,539	10,000	9,800	8,400
Other German	3,568	3,552	1,743	1,000	600
Austria	572	474	474	500	255
Hungary	661	661	800	900	1,010
Sweden	800	796	986	1,074	800
Norway	2,650	2,500	2,640	2,425	2,412
Italy	1,000	1,400	1,480	1,380	1,140
Russia	3,000	3,000	3,000	2,681	3,081
Total Europe	71,740	66,249	64,565	59,297	53,866
NORTH AMERICA.					
United States	51,574	40,467	32,000	27,000	23,000
Canada	1,055	500	500	50	50
Newfoundland:					
Bett's Cove	1,053	1,500	1,718	1,500	1,500
Mexico	489	401	333	400	400
Total North America	54,171	42,868	34,551	28,950	24,950
SOUTH AMERICA.					
Chili	41,093	42,918	37,989	42,916	49,318
Bolivia					
Corocoro	4,000	3,250	2,655	2,000	2,000
Peru	395	440	615	600	600
Venezuela					
New Quebrada	4,018	3,700	2,822	1,800	1,597
Argentine Republic	299	800	307	300	300
Total South America	49,805	51,108	44,389	47,616	53,815
AFRICA.					
Algiers	600	600	600	500	500
Cape of Good Hope:					
Cape Copper Company	5,975	5,716	3,467	4,739	4,328
Total Africa	6,575	6,316	4,067	5,239	4,828
ASIA.					
Japan	5,000	2,800	1,900	1,900	1,900
Total Asia	5,000	2,800	1,900	1,900	1,900
Australia	12,500	8,513	10,000	9,700	9,500

RECAPITULATION.

	1883.	1882.	1881.	1880.	1879.
Europe	71,740	66,249	64,565	59,297	53,866
North America	54,171	42,868	34,551	28,950	24,950
South America	49,805	51,108	44,389	47,616	53,815
Africa	6,575	6,316	4,067	5,239	4,828
Asia	5,000	2,800	1,900	1,900	1,900
Australia	12,500	8,513	10,000	9,700	9,500
Total	199,791	177,853	159,802	152,702	148,859

Great Britain.—The decline in the production of the British mines has been continued, and they have practically ceased to exert any influence.

Production of copper in Great Britain.

Years.	Ore.	Copper.	Years.	Ore.	Copper.
	Long tons.	*Long tons.*		*Long tons.*	*Long tons.*
1860	236,696	15,968	1876	79,252	4,694
1865	198,298	11,888	1877	73,143	4,486
1870	106,698	7,175	1878	56,094	3,952
1871	97,129	6,280	1879	51,035	3,462
1872	91,893	5,703	1880	52,118	3,662
1873	80,188	5,240	1881	52,556	3,875
1874	78,521	4,981	1882	52,810	3,464
1875	71,528	4,323	1883	46,820	2,639

The official figures for 1884 show a slight increase, to 3,300 tons, as the yield of the Cornish mines.

Great Britain, however, handles more than half the copper produced in the world, and the figures relating to that trade are of the greatest importance.

British imports and exports of copper.

Years.	Imports of—		Total imports.	Exports.
	Bars, cakes, and ingots.	Copper in ores and furnace products.		
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
1860	12,142	12,715	24,857	28,117
1865	22,137	25,922	47,059	41,266
1870	30,734	27,025	57,759	53,698
1871	32,228	23,671	55,899	56,623
1872	49,000	21,703	70,703	53,195
1873	35,840	26,756	62,596	55,716
1874	39,906	27,894	67,800	50,742
1875	41,931	29,483	71,414	51,870
1876	38,145	38,101	76,246	52,462
1877	29,743	63,582	93,325	54,609
1878	39,360	48,212	87,572	55,661
1879	46,670	50,421	97,091	62,412
1880	36,509	56,225	92,734	50,452
1881	32,170	54,067	86,237	61,099
1882	35,509	58,366	93,875	55,698
1883	35,653	63,493	99,146	59,360
1884	29,815	83,091	112,906	64,691

The following figures from the Board of Trade returns for the seven years since 1878 show in detail the form in which the copper is brought into Great Britain and in what form it is exported:

Imports of copper into Great Britain from 1878 to 1884 inclusive.

Character.	1878.	1879.	1880.	1881.	1882.	1883.	1884.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Pure in pyrites	14,443	12,040	16,446	13,551	15,672	15,016	14,077
Pure in precipitate	13,173	18,159	18,205	18,619	17,925	22,948	31,738
Pure in ore	15,441	13,173	14,976	15,396	15,499	15,880	24,842
Pure in regulus	5,155	7,049	6,598	6,501	9,270	9,649	12,434
Bars, cakes, etc	39,360	46,670	36,509	32,170	35,509	35,653	29,815
Total	87,572	97,091	92,734	86,237	93,875	99,146	112,906

Exports of copper from Great Britain from 1878 to 1884 inclusive.

Character.	1878.	1879.	1880.	1881.	1882.	1883.	1884.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Raw English	17,819	16,370	15,200	18,737	12,776	16,777	17,943
Sheets	12,269	15,403	16,582	15,960	15,696	16,071	20,609
Yellow metal, at 60 per cent	8,744	10,042	10,128	9,930	10,993	11,918	11,662
Brass, at 70 per cent	3,450	2,761	2,677	3,263	3,400	3,381	3,735
	42,282	44,575	44,587	47,890	42,865	48,147	53,949
Fine foreign	12,719	17,837	14,895	13,799	12,818	11,212	10,742
Total	55,001	62,412	59,482	61,689	55,683	59,359	64,691

Turning first to the imports of pyrites, we find the following table of the imports and their source since 1873 in the volume of the Mineral Statistics of Great Britain:

Imports of pyrites into Great Britain.

Years.	Norway.	Portugal.	Spain.	Germany.	Other countries.	Total.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons*	*Long tons.*	*Long tons.*
1873	67,462	199,559	246,692	....	6,634	520,347
1874	41,044	162,569	294,117	....	907	498,637
1875	21,820	165,433	344,019	....	6,288	537,560
1876	7,888	56,379	419,068	....	21,417	504,752
1877	8,564	149,562	498,977	....	22,209	679,312
1878	5,773	136,705	319,561	....	12,318	474,357
1879	8,465	82,529	374,505	....	15,783	481,282
1880	10,953	168,319	463,198	8,695	8,684	659,849
1881	6,008	140,079	379,216	8,412	8,663	542,378
1882	....	114,182	497,807	....	15,761	627,750
1883	1,271	121,187	473,249	....	5,581	601,288
1884	....	....	....	....	....	568,078

Spain and Portugal therefore practically monopolize the business.

The following table exhibits the quantity of burned pyrites treated at the twenty-two metal extraction works, together with the quantities of metallic copper and gold and silver extracted by the Claudet process:

Metals extracted from burned cupriferous pyrites.

Years.	Ore.	Copper.	Gold.	Silver.
	Long tons.	*Long tons.*	*Ounces.*	*Ounces.*
1880	415,567	15,000	1,043	248,961
1881	398,737	14,000	1,496	256,463
1882	434,427	15,360	1,800	400,000
1883	439,156	15,379	1,511	348,210

Prof. G. Lunge, of Zurich, the great authority on the manufacture of sulphuric acid and soda, has made some interesting calculations based on statistical data, to show for what purposes and in what quantities sulphuric acid is made in England. These computations are of interest, as they bear directly upon the prosperity of the great Spanish pyrites mines, and trace the causes which have no mean influence upon that important supply of copper, the metal extracted from pyrites cinder. The following table contains the principal data:

Sulphuric acid produced in Great Britain.

Years.	Made from pyrites.	Pyrites acid used for manufacture of sulphate of soda.	Pyrites acid used for other purposes.	Acid made from brimstone.	Total acid made.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1878	747,900	417,406	330,494	124,271	872,171
1879	716,625	445,265	271,360	116,[illegible]	[illegible]
1880	771,771	501,612	270,159	123,658	895,429
1881	736,797	475,724	261,073	115,509	852,306
1882	806,793	472,151	334,642	124,742	931,535
1883	815,574	484,252	331,322	126,994	942,568

The principal quantity of sulphuric acid is therefore consumed in the manufacture of soda. The ammonia-soda processes, which avoid the use of sulphuric acid, have been looked upon as seriously threatening the pyrites mines by diverting from them their most important customer. It is not now denied that the new processes can produce soda cheaper than the old Leblanc process, but the latter has apparently obtained a new lease of life through the increased value of the hydrochloric acid, formerly a waste by-product, and the substitution of the one method of manufacturing soda by the other is not likely to progress with that resistless rapidity which was claimed for it not long ago. The other principal consumer of pyrites acid, taking almost all of the heavy quantities under "pyrites acid for other purposes" in the above table, is the great fertilizer industry, whose requirements, it will be noted, are subject to wide fluctuations. It strongly illustrates the interdependence of modern industrial mining and agricultural industries that an important source of the supply of copper should fluctuate through the intermediary of two other industries with the requirements of the farmers of Great Britain and other countries for fertilizers.

The Spanish pyrites companies, recognizing the danger that their market might be seriously curtailed, have aided the struggling Leblanc soda makers by reducing the price of sulphur in pyrites materially on the contracts renewed in 1884.

Imports of precipitate and regulus into Great Britain.

Countries.	1880.	1881.	1882.	1883.	1884.	Containing fine copper (estimated).
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Portugal	5,388	8,144	7,901	3,879	7,161 }	22,[illegible]
Spain	[illegible]	21,647	21,[illegible]	35,[illegible]	37,[illegible] }	
Chili	14,609	8,116	10,[illegible]	6,[illegible]	16,[illegible]	4,315
Other countries	4,562	6,309	9,710	12,[illegible]	10,[illegible]	7,619
Total	45,001	44,216	49,207	57,726	62,410	....
Pure copper	24,773	25,110	27,305	22,907	24,173	....

By far the greater quantity of the material enumerated as coming from the Peninsula is precipitate, only a comparatively small part of the product being "regulus" or "matte," as we are accustomed to call that furnace product. All of the Chili imports are regulus. Among the "other countries" the United States, of course, are beginning to take the leading part. For 1884 the quantity is estimated to have contained 2,722 long tons fine copper.

The third source of supply of the copper metallurgical industries of Great Britain is ore, from the following countries, as enumerated by the latest Board of Trade returns:

Imports of copper ore into Great Britain.

Countries.	Quantities.			Values.			Average value per ton.		
	1882.	1883.	1884.	1882.	1883.	1884.	1882.	1883.	1884.
	Long tons.	*Long tons.*	*Long tons.*						
Italy	12,[illegible]	9,408	11,109	£[illegible]	£[illegible]	£[illegible],140	£34.[illegible]	£47.11	£34.79
Venezuela	25,[illegible]	31,344	25,[illegible]	199,237	214,191	159,[illegible]	7.43	6.73	6.16
Bolivia	8,714	1,[illegible]	2,[illegible]	46,784	13,344	13,390	12.[illegible]	12.[illegible]	8.61
Chili	[illegible]	1,[illegible]	245	5,902	12,901	4,[illegible]	16.[illegible]	12.17	19.[illegible]
Cape of Good Hope	10,052	19,917	22,[illegible]	301,019	252,[illegible]	342,971	[illegible]	17.71	15.35
British North America	15,168	10,976	2,067	90,213	65,[illegible]	8,[illegible]	5.95	6.04	4.35
Other countries	28,652	31,748	60,586	290,162	[illegible]	798,637	8.[illegible]	11.65	13.00
Total ore	108,[illegible]	105,979	134,214	1,085,904	1,095,016	1,378,044	10.02	10.35	11.09
Total pure copper	15,449	15,[illegible]	24,842	....	....	....	....	....	....
Average percentage	15.00	15.00	20.00	....	....	....	....	....	....

In this instance, too, the official Board of Trade returns have not kept pace with the latest developments, and the most important shipments in 1884, those from the United States, disappear in "other countries." An estimate places the contents of fine copper at 11,023 long tons. For 1883 the special return already alluded to shows the receipts to have been 10,732 tons, almost exclusively the product of Montana, estimated to have contained 4,940 tons fine copper. Norway sent 3,382 tons, Portugal 1,822 tons, Spain 2,271 tons, Algeria 5,161 tons, South Australia 3,756 tons, and Peru 1,334 tons. The decline in the values of the low-grade ores is well illustrated in the above table. The richest material, of course, is dependent more upon grade, and the average value of the shipments from other countries is affected by the particularly high grade of the new American supply, much of which, too, was argentiferous.

The chief source of supply of black copper or "bars," averaging 96 per cent., is Chili, the United States having, however, begun to contribute copper in this form. Refined copper comes chiefly from Australia, going to London. The following figures will show how largely these two countries participate in furnishing the manufacturers of Great Britain with raw material:

Imports of copper, wrought and unwrought, into Great Britain.

Countries.	1880.	1881.	1882.	1883.	1884.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Chili	24,2[illegible]	21,019	22,5[illegible]	22,7[illegible]	22,[illegible]
Australia	9,406	9,150	9,132	9,5[illegible]	[illegible]
Other countries	2,946	2,001	4,773	3,[illegible]	7,6[illegible]
Total	36,[illegible]	32,170	35,[illegible]	[illegible]	3[illegible],815

The receipts from Australia were derived from the different colonies as follows in 1883: New South Wales, 6,729 tons; South Australia, 2,442 tons; Victoria, 261 tons; and Queensland, 98 tons. Among the "other countries," according to the special return of 1883, the United States occupied the first rank, with 1,866 tons; Spain contributing 437 tons, Peru 291 tons, and France, Turkey, Japan, Argentine Republic, and others, smaller quantities.

Messrs. James Lewis & Son, of Liverpool, estimate as follows the imports of other than Chili copper into Liverpool and Swansea during the years 1882, 1883, 1884:

Imports of copper other than from Chili, at Liverpool and Swansea.

Sources.	1882.	1883.	1884.
	Tons fine.	*Tons fine.*	*Tons fine.*
From United States	745	9,610	17,[illegible]
Canada	347	[illegible]	[illegible]
Mexico	[illegible]	[illegible]	[illegible]
Peru	[illegible]	[illegible]	[illegible]
River Plate	[illegible]	519	181
New Quebrada	2,104	3,[illegible]	2,675
Newfoundland	1,[illegible]	1,155	224
Spain	447	2,[illegible]	2,[illegible]
Portugal	17	129	117
Italy	1,[illegible]	1,051	1,[illegible]
Norway	446	[illegible]	[illegible]
Cape of Good Hope	5,[illegible]	5,070	6,043
Australia	112	[illegible]	[illegible]
Elsewhere	825	948	[illegible]
Precipitate	8,757	11,[illegible]	10,[illegible]
Total	24,450	[illegible],437	[illegible]

The bulk of the Australian copper goes to London, and is not, therefore, included in the above statement, which is particularly interesting as showing how heavy were the receipts of material from the United States, the bulk being from Montana. A good deal of the latter has, however, also gone to France and Germany.

Turning now to the exports of copper and its manufactures, it is of interest to note, aside from the volume of this movement, its direction, as revealing who the principal customers of Great Britain are:

Exports of British copper (ingots, bars, and slabs) from Great Britain.

To—	1881.	1882.	1883.	1884.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
Germany	3,667	2,407	4,508	4,978
Holland	2,714	1,262	2,341	2,989
Belgium	1,869	2,126	2,307	2,108
France	7,172	5,962	5,920	5,648
British India	1,969	20	201	945
Other countries	2,211	667	1,456	2,870
Total	18,703	12,777	16,860	17,943

The continent of Europe is the greatest consumer of unwrought copper in bricks and pigs, the bulk of the quantities enumerated under "other countries" going to Italy and Austria. In addition to this there were exported in 1883, according to special return, 11,178 tons of foreign copper, of which Germany took 3,057 tons, Holland 2,872 tons, Belgium 954 tons, France 2,180 tons, British India 1,087 tons, and Russia 530 tons.

Exports of wrought or manufactured copper from Great Britain.

To—	1881.	1882.	1883.	1884.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
Russia	1,315	458	540	299
Germany	702	327	318	269
Holland	500	300	272	342
France	612	1,131	147	349
Italy	496	429	594	477
Turkey	1,237	1,404	1,666	2,608
Egypt	1,232	569	906	1,105
British India	4,950	6,870	629	617
Other countries	4,667	4,034	7,298	10,181
			2,966	4,828
Total	15,660	15,196	16,067	20,669

The most interesting figure in this table is that proving the heavy increase in the shipments to India, confirming the impression generally prevailing that the merchants in that country have been induced by the decline to stock heavily. How far they have anticipated future wants is not known. It is to be noted, however, that American refiners have made successful efforts in this market.

It is a curious fact, which is not widely known, that the heavy consumption of India is due largely to a religious rite of the natives. At certain seasons of the year small cups of sheet copper about an inch in diameter and an inch and a half deep are filled with rice, and are thrown into the rivers as an offering, with religious ceremonies. The quantity of copper thus annually consumed is very heavy, India sheets being an important article of commerce.

Exports of manufactures of brass from Great Britain.

To—	1881.	1882.	1883.	1884.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
All countries	4,667	4,930	4,830	5,337

Exports of yellow metal from Great Britain.

To—	1881.	1882.	1883.	1884.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
British India	7,137	8,249	10,495	10,494
Other countries	9,531	9,909	9,259	8,843
Total	16,668	18,158	19,754	19,337

The 1883 special return shows that 4,252 tons went to the Continent, Italy taking 920 tons, Germany 905 tons, Norway 662 tons, Holland 506 tons, France 374 tons, Belgium 228 tons, and Sweden 203 tons. Hong-Kong received 1,608 tons, Asia altogether taking 12,792 tons, while Australia bought 748 tons, and North and South America 1,833 tons, of which 781 tons came to this country.

Chili.—Little that is positive is known as to the capacity of Chili's producers to resist low prices. The two English companies working in that country, the Copiapo and the Panulcillo, do not sufficiently represent the average condition of the great number of the producers to admit of any deductions from their published annual reports. The following statement of the exports of copper from Chili will best serve to show what has been the record of this country for a long series of years:

Exports of copper from Chili.

Years.	Tons.	Years.	Tons.
1855	20,250	1870	40,120
1856	21,938	1871	41,300
1857	25,496	1872	46,357
1858	30,470	1873	42,165
1859	28,250	1874	42,240
1860	36,280	1875	45 490
1861	35,271	1876	50,740
1862	42,100	1877	45,460
1863	52,540	1878	46,770
1864	47,500	1879	49,300
1865	46,337	1880	42,900
1866	44,325	1881	38,080
1867	44,654	1882	42,900
1868	43,080	1883	41,230
1869	54,367	1884	43,700

The principal reason why lower prices have had no effect in curtailing the output of Chili in 1884 has been that exchange has declined almost as heavily as the price of copper. When in January, 1883, Chili bars were quoted at £65 10*s*. in London, the rate of exchange in Valparaiso was 37*d*. In December, 1884, when Chili bars were sold at £47 5*s*., exchange had fallen to 27½*d*., thus showing a decline in the latter of 26 per cent., and in the value of copper of 28 per cent. In addition to this the export duty on bars has been repealed, amounting to about one quarter of 1 cent per pound, and other burdens have been lightened, which, together with that exemption of export duty, foot up in value to about one-half of 1 cent per pound.

Spain.—Almost the entire copper product of Spain and of Portugal is taken from the great pyrites mines of the Peninsula and is shipped in two forms—not counting a small quantity of "regulus" or matte—as precipitate and as crude pyrites which is used for the manufacture of sulphuric acid, the copper, silver, and gold being extracted from the residues. The Spanish export statistics show only the exports of "cobre en barras," presumably giving the gross weight of the precipitate, and the exports of pyrites, the copper contents of which appear in the import statistics of Great Britain and in the statistics of production of France and Germany.

Exports of precipitate and pyrites from Spain.

Years.	Precipitate.	Pyrites.
	Metric tons.	*Metric tons.*
1878	1,377	427,259
1879	20,834	459,576
1880	20,940	501,425
1881	17,710	432,475
1882	22,686	571,441
1883	24,290	506,565
1883 (eight months)	15,848	467,082
1884 (eight months)	11,162	405,673

The only explanation as yet received in relation to the falling off in shipments as revealed by the figures for the first eight months of 1883 and 1884 is that the cholera scare may have delayed exports.

An interesting estimate of the actual output of copper in the Peninsula, including the fine copper both in precipitate and pyrites, has been made by Messrs. H. R. Merton & Co., of London, who place the product as follows:

Copper production of Spain and Portugal.

Mines.	1883.	1882.	1881.	1880.	1879.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Rio Tinto (Spain)	20,473	17,320	16,906	16,215	13,751
Tharsis (Spain)	9,800	9,000	10,268	9,151	11,234
Mason & Barry (Port.)	5,000	5,000	8,170	6,000	4,662
Sevilla (Spain)	2,036	1,856	1,340	1,765	1,369
Portugueza (Port.)	2,307	1,700	1,410	1,000	770
Poderosa (Spain)	1,000	800	800	800	900
Total	42,655	36,774	38,894	35,474	32,697

The Rio Tinto mines have more than any others excited the interest of American producers on account of their rapid development, which it is well known has not yet reached its maximum, on account of the undoubtedly enormous quantity of ore available and the low cost of production. On the latter point we possess some figures, compiled by M. E. Cumenge, an eminent French mining engineer, who made an elaborate report in the year 1883. With the old method of extraction by roasting in heaps, leaching with water, and precipitating with cast iron, he places the cost at which the ingot copper can be placed on the London market at £30 per ton, assuming that only one-half of the ore used has been taken from the open-cut workings, where it can be obtained more cheaply. The Doetsch process, it appears, effects a saving of about £4 per ton of copper. Even assuming that only 15,000 tons of copper were produced, and that that part of the business was forced to provide for the fixed charges of the company, say about £12 per ton, the miner could thrive with Chili bars below £50 in London. It is not therefore likely that there will be any decline in the output of the Rio Tinto mines.

The production of the Rio Tinto mines for a series of years has been as follows:

Production of the Rio Tinto mines.

Years.	Pyrites for shipment.	For extraction of copper by local treatment.	Total.	Actual consumption of pyrites in England, Germany, etc.	Average copper contents of ore mined.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Per cent.*
1877	251, 360	520, 391	771, 751		
1878	218, 810	[illegible]	871, 167		
1879	242, 241	[illegible]	[illegible]	298, 949	
1880	377, 590	637, 567	915, 157	374, 201	2. 619
1881	248, 098	743, 949	992, 047	356, 827	2. 730
1882	289, 924	659, 397	949, 321	[illegible]	2. 865
1883	313, 201	[illegible]	1, [illegible], 973	298, 104	2. 968

The production of copper by local treatment at the Rio Tinto mines was as follows since 1876:

Production of metallic copper at Rio Tinto.

Years.	Tons.
1876	1, 112
1877	2, 954
1878	4, [illegible]
1879	8, 494
1880	10, 065
1881	11, 183
1882	11, 469
1883	14, 459

In the annual report of the company for 1883 the statement is made that the works for the manufacture of copper are being laid out to reach in a few years 20,000 tons of 21 hundredweights, or 23,500 short tons.

This enormously rapid increase was not obtained without a heavy additional outlay, the growth of which the following table sets forth. The third column, "creditors," is made up of current and open accounts and bills payable. It is added merely to serve as a guide in showing why the share capital and the bonded debt were increased:

Years.	Share capital.	Mortgage bonds.	Creditors.
1879	£2,250,000	£2,741,380	£1,807,112
1880	2,250,000	4,201,840	473,861
1881	3,250,000	2,453,160	256,193
1882	3,250,000	2,418,940	781,187
1883	3,250,000	2,385,020	992,678

The "profit on sale of produce," the net profit, and the dividends paid were as under for a series of years:

Years.	Profit on sale of produce.	Net profit.	Dividends.
1879	£443,930	£114,419	£112,500
1880	611,340	181,783	180,000
1881	622,786	a405,456	395,000
1882	658,985	477,184	455,000
1883	691,571	459,678	455,000

a Including £80,000 reserved from premiums on new issue of shares.

During 1882 and 1883 the dividends were at the rate of 14 per cent. on the nominal value of the shares. The usual interim dividend was £195,000, which has this year been reduced by £32,500, to £162,500. In 1879 there were outstanding £882,480 of 7 per cent. bonds, the balance of about £2,000,000 bonds being security for the floating debt. These were replaced by an issue of a more favorable character. In 1881 the share capital was increased by 100,000 shares, which produced £2,364,550, and with which the outstanding balance of the 5 per cent. Spanish coupon bonds were paid off at a cost of £1,734,600, leaving a surplus of £629,950. This did not prove sufficient to clear off the floating debt, so that the company had still to borrow £200,000 to cover the deficiency, besides what was required for working capital. Further additions to plant were made, and in 1883 it was decided, in order to consolidate the floating debt (then about £680,000), to provide a working capital, and to obtain funds to complete works, to create £1,200,000 second-mortgage bonds. The company must therefore provide for interest on over £3,500,000 bonds, and earn fair dividends on £3,250,000 share capital. Before any money can be applied for dividends on the latter a profit of about $850,000 must be made annually. On the other hand the company has developed ore reserves estimated at 100,000,000 tons, and has accumulated heaps from which copper is gradually being extracted, which are known to contain 40,000 long tons of copper, standing in the books at a cost of £6 7*s.* 6*d.*, on which the only cost is that of precipitation, estimated at £15 per ton.

The history and the present condition of the Rio Tinto Company have been dwelt upon because it is the greatest of the pyrites mines of the Peninsula, and is their best representative. The Tharsis company is the next one in importance. The amount of ore raised from the Tharsis and Calanas mines was 490,033 tons in 1883, against 486,860 tons in 1882, the shipments of pyrites being 186,366 tons of lump and 15,952 tons of smalls in 1883, against 218,218 tons in 1882. The quantity of precipitate shipped was larger in 1883, being 6,717 tons in that year, against 5,534 tons in 1882. The production of iron ore was 196,475, of which 179,811 tons were invoiced. The net profits of this enormous business were £355,689, including a balance, carried forward from the preceding year, of £21,197. Out of this, a dividend of £323,032, or 27½ per cent. on the capital of the company, was paid, carrying £10,000 to the reserve fund, and a balance of £22,648. Since operations were commenced in December, 1866, the gross profits of the concern have been, in seventeen years, £4,771,148, or, roughly, $23,150,000, which has been appropriated as follows: £3,324,354 dividends, £684,578 written off for property and plant, £471,568 for salaries, management, interest, and bad debts, £100,000 for sinking fund for railroad and docks, £10,000 for alteration of railroad, and £160,000 for reserve fund. The capital has steadily increased from £300,000 in 1868 to £785,071 in 1869, £838,797 in 1870, £900,000 in 1872, £1,136,660 in 1879, £1,143,560 in 1882, and £1,174,660 in 1883, at which figure it now stands, 37,670 shares, at £2, being still unissued and held for emergencies. The company had a debenture debt on December 31, 1883, of £279,100, of which £143,100 have since fallen due, and have been paid, leaving the amount of outstanding bonds £66,000, bearing 5 per cent., and £70,000 bearing 4 per cent. interest.

Portugal.—The principal mines in Portugal are those of the Mason & Barry Co., limited, the San Domingos, which is in many respects similar to the Rio Tinto deposit. The company which succeeded to the business of the firm of Mason & Barry has a capital of £2,100,000, of which 185,164 £10 shares have been issued. Since 1878 it has distributed among its shareholders £1,095,177 in dividends out of a total net profit of £1,289,653, having paid during the six years £60,868 interest on mortgage debentures, having written off £223,673 for property, plant, and open cost at mine, £60,000 for good will and leases, invested £23,943 in consols, placed £135,000 to the credit of rest account, from which £50,000 were transferred to profit and loss account. The product of the mine was 405,029 tons in 1882 and 382,555 tons in 1883, of which 129,437 and 123,450 tons of pyrites were shipped to sulphuric-acid makers, the company having works of its own in England. The balance of the product was worked for copper on the spot, the quantity of fine copper made not being stated, however. There are now 2,000,000 tons of ore undergoing extraction. The profit for 1883 was only £195,993, as compared with £276,719 during the preceding year, and

£50,000 were transferred from the reserve account to make up the usual dividend of 12½ per cent. per annum.

Germany.—Further progress has been made during the year 1883 in the output of the production of copper in Germany. Official statistics are now gathered for the entire empire and these have been adopted for the years 1882 and 1883. It is presumed, however, that they do not include the product of the Hamburg electrolytic works.

Production of copper in Prussia and in the Mansfeld district.

Years.	Prussia.	Mansfeld district.
	Metric tons.	*Metric tons.*
1875	7,212	[illegible]
1876	8,295	[illegible]
1877	8,661	7,971
1878	9,006	8,546
1879	10,165	9,813
1880	14,898	10,989
1881	15,763	11,666
1882	a16,658	11,691
1883	a18,194	12,836

a German Empire, assuming matte produced to carry 50 per cent. of copper.

The product of the Mansfeld district, practically the yield of one very large corporation, has been specially given because, outside of the Rammelsberg mine, it is the only concern working an important deposit. The balance of the copper product of the empire is obtained partially from the extraction of the metal from the residues of roasted imported iron pyrites and from a scattered quantity of ore obtained as a by-product in mining for lead and zinc. A considerable quantity of Spanish and Portuguese precipitate is refined by one large copper-rolling establishment.

The Mansfelder Kupferbauende Gewerkschaft, one of the great copper producers of the world, hoisted from its narrow bed of cupriferous shale 536,086 tons of ore, and made from it 36,687 metric tons of matte, which in roasting yielded a by-product of 17,487 tons of sulphuric acid. It turned out 12,836 metric tons of fine copper, and 64,463 kilograms of silver, and made a profit of 3,091,699 marks in the year 1883. Referring the entire profit to the copper alone, this sum represents a profit of 3.2 cents per pound of ingot copper, or £15¾ per long ton, so that the decline of the year 1884 does not reduce the earnings below its expenditures. The company is managed with the closest economy, and with a constant watchfulness so far as the technical details of mining and metallurgy are concerned; and it is not too much to say that without the exercise of these precautions the mines would have been abandoned years since, as the bituminous shale hoisted does not average more than 2.85 per cent. of copper, and 0.015 per cent., or 4.37 ounces, of silver per ton.

The export movement from Germany may be traced from the following general table:

Exports of copper and copper manufactures from Germany.

Character.	1879.	1880.	1881.	1882.	1883.
	Metric tons.	*Metric tons.*	*Metric tons.*	*Metric tons.*	*Metric tons.*
Ingot copper and brass	9,287	7,204	7,704	6,007	5,751
Copper rods, sheet, and wire	3,290	5,428	5,130	1,997	[illegible]
Manufactured copper	2,973	4,195	4,737	3,944	[illegible]
Total	15,559	16,827	17,571	11,948	11,677

Official statistics, kindly prepared specially at the request of the United States Geological Survey by the imperial German Bureau of Statistics, give the destination of the exports of copper as follows:

Destination of exports of copper from Germany.

Destination.	Ingot copper.		Sheet and rods.		Wire and telegraph cable.	
	1882.	1883.	1882.	1883.	1882.	1883.
	Metric tons.	*Metric tons.*	*Metric tons.*	*Metric tons.*	*Metric tons.*	*Metric tons.*
Bremen	....	....	62	30	....	8
Hamburg	373	126	174	263	34	52
Russia	325	142	154	297	40	47
Austria	3,788	4,402	93	127	47	136
France	349	119	26	....	34	17
Belgium	784	422	136	18	9	10
Netherlands	190	188	256	123	100	106
Great Britain	....	96	....	45	58	63
Italy	....	79	188	138	35	56
Other countries	286	137	270	339	251	184
Total	6,095	5,751	1,409	1,380	608	679

In addition to these exports Germany shipped to other countries in 1882 1,066 tons, and in 1883 955 metric tons of "coarse" copper and brass forgings and tubes, 203 and 187 tons, respectively, of copper-nickel and brass wire cloth, and 2,584 and 2,725 tons, respectively, of light copper and brass forgings. In the aggregate its exports of ingot copper and manufactures of copper and brass were 11,948 tons in 1882 and 11,677 tons in 1883.

The difficulty usually encountered in tracing the import and export movement of Germany, growing out of the fact that Hamburg is a free port, is enhanced in the case of copper, because there is a local reduction works, the product of which is not known, and which is not returned in any statistics. Treating ores and furnace material by the electrolytic process, it might be believed that the special returns of argentiferous and auriferous material might furnish a clue, but unfortunately Hamburg is the port of entry of the foreign material treated at the Mansfeld works. In 1883 812 tons of argentiferous ore and 575 tons of argentiferous copper were imported. A part of the latter may have gone to bluestone works. From a statement of the quantity of copper deposited daily by the electrolytic process at the Hamburg works, it is estimated that its output is 750 metric tons per annum.

Still the exports via Hamburg and Bremen are comparatively light, as the table given proves, and the general result is not much affected. It proves that Austria receives the bulk of the exports from Germany so far as ingot is concerned. To what extent this is merely material in transit it is difficult to ascertain so far as the raw material is concerned. Germany is a considerably heavier importer than exporter, while on the other hand it exports more manufactured copper than it receives from other quarters. As is usually the case, its exports of the more finished products are much more widely scattered, going in small quantities to many different countries. The following table gives the imports of copper and copper manufactures into Germany. During the present year the United States have contributed a larger share, numerous sample lots of ingot copper and of copper matte having gone to Germany, which also receives considerable Lake copper, directly and indirectly, from England and France. The exact figures for the direct shipments are not available, while those indirectly made cannot be traced.

Imports of copper and copper manufactures into Germany.

Character.	1879.	1880.	1881.	1882.
	Metric tons.	*Metric tons.*	*Metric tons.*	*Metric tons.*
Ingot copper and brass	13,378	12,719	11,372	10,579
Copper rods, sheet and wire	608	770	437	290
Manufactured copper	1,201	1,015	1,119	1,015
Total	15,187	14,504	12,928	11,884

Cape of Good Hope.—Regular contributors to the world's markets for many years past have been the mines of the Cape Copper Company, limited, an English corporation which has been exceptionally successful. The principal producer at the present time is the Ookiep mine, which in 1882–'83 yielded 15,827 tons of 28.6 per cent. ore and in 1883–'84 15,588 tons of 29.23 per cent. ore, while 1,728 tons of 37.56 per cent. ore in the former year, and 1,800 tons of 39.16 per cent. ore in the latter year were raised from the Specktakel mine; the Springbok, the early wonder of the district, being now practically exhausted.

The company has its own smelting works in England, and turns out annually from 5,000 to 5,300 long tons of fine copper. The net profits in the fiscal year 1882–'83 were £145,465, and in the last year £101,135, the cost of production varying little from £207,000 annually, or 8*s.* per unit, equivalent to £40 in Chili bars. So long as the reserves of high-grade ore last the company will remain a steady producer of metal. The yield in 1884 is estimated at 6,699 tons of fine copper.

As one of the phases of the new German colonial policy, attention of German adventurers has been directed to the copper resources of Angra Pequeña, and exploration is now going on in a vigorous manner.

Australia.—The principal increase in the output of the Australian colonies has come from New South Wales, South Australia barely holding its own, as the following figures, compiled from various sources, show:

Exports of copper and furnace products from the Australian colonies.

Years.	South Australia.		New South Wales.		Queensland.
	Ingots.	Ores.	Ingots.	Ore and regulus.	Ingots.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
1870	5,471	20,886	994	6	[illegible]
1871	6,300	20,137	1,059	94	[illegible]
1872	7,452	26,964	1,035	417	2,448
1873	7,097	27,382	2,795	61	(?)
1874	6,629	22,864	3,638	522	(?)
1875	6,842	26,436	[illegible]	157	(?)
1876	5,469	22,669	3,106	160	2,105
1877	5,148	18,539	4,158	[illegible]	844
1878	5,594	17,007	4,986	[illegible]	643
1879	(?)	(?)	4,107	56	....
1880	(?)	(?)	5,262	182	....
1881	(?)	(?)	5,301	123	....
1882	3,847	25,897	4,805	92	....
1883	2,442	a 3,756	6,073	94	a 80

a Receipts in England in 1882.

The principal mine in New South Wales, and one which has been exploited for a long time, is the Great Cobar, which in 1883 made 2,401 tons of fine copper from 18,096 tons of ore. The mine inspectors report that it has very large reserves. The Nymagee Company produced 1,714 long tons of fine copper from 10,236 tons of ore, and the Burraga 520 tons from 6,150 tons of ore. How far these mines will be able to outlive low prices, with the limited transportation facilities now at their service, and the frequent troubles from drought, cannot be stated, since no reports concerning their financial affairs are available. It is certain, however, that the growing activity in prospecting in the colony will be checked.

In South Australia the business report of the English and Australian Copper Company, owners of the Burra Burra mines, clearly reflects the distress caused by low prices. For the fiscal year ending June 30, 1883, the two smelting works of the company, at Port Adelaide and at Newcastle, received only 7,683 tons of matte, against 10,715 tons during the previous year, the falling off being, however, largely due to drought. On a product of about 3,452,000 pounds of ingot, the company made only a profit of £1,435.

France.—The following is a statement of the quantity of copper produced in French works, chiefly from imported ores and furnace material:

Production of copper in France.

Years.	Metric tons.	Years.	Metric tons.
1870	2,100	1877	[illegible]
1871	2,720	1878	[illegible]
1872	2,900	1879	[illegible]
1873	2,140	1880	[illegible]
1874	[illegible]	1881	[illegible]
1875	[illegible]	1882	[illegible]
1876	[illegible]		

France is a very small copper producer, but in 1883 handled an unusual amount of foreign ore, comparatively speaking, large shipments of arsenical medium-grade material having been made to the Septemes works, where the Manhès copper matte Bessemerizing process was applied to it, with, it is claimed, great success. This ore was shipped from Butte, via San Francisco, around Cape Horn.

While unimportant as a producer of copper, France is a very heavy consumer, and is particularly interesting from that point of view to the Lake producers, taking as it does the bulk of the Lake copper exported. According to statistics published in England, the receipts of American copper in 1884 were 7,260 long tons; of Chili bars, ingots, and barilla, 11,086 long tons, and of copper from sundry sources 337 tons, thus indicating total imports of 18,683 tons. One of the principal French copper manufacturing industries is art casting, in which the value of the raw material used bears a comparatively insignificant proportion to the value of the finished product. To insure a faultless casting the very best quality of copper is sought, and Lake has obtained a firm foothold in that market.

The following figures, compiled by English authorities, show the magnitude of the French copper trade:

The French copper trade.

Years.	Imports, all kinds direct.	Imports of American, etc.	Imports of Chili.
	Long tons.	*Long tons.*	*Long tons.*
1876	16,416	4,220	12,196
1877	13,015	4,030	8,985
1878	13,094	4,016	9,078
1879	10,402	4,675	5,727
1880	11,818	320	11,498
1881	16,436	3,205	13,231
1882	13,573	1,379	12,194
1883	20,894	4,830	16,064
1884	18,683	7,597	11,086

Austria.—From official data kindly furnished by O. von Ernst we have compiled the following statement of the production of copper in Austria since 1879:

Production of copper in Austria.

Years.	Metric tons.
1879	259
1880	568
1881	482
1882	492
1883	661

Over one-half of this product or 323 tons is produced at the Mitterberger Hütte, Salzburg. At Witkowitz, Moravia, 112 tons of precipitate was made from 149,538 tons of roasted pyrites, partly imported, the product being sent out of the country to be refined. The balance was made at two works in Tyrol, one of them, the Brixlegg works, belonging to the Government.

The native copper industry is therefore very unimportant, and Austria must rely largely for its supplies of the metal upon foreign countries. In 1883 the imports were 6,646 metric tons of copper, of which 6,260 tons came from Germany, and only 295 tons by way of Trieste. The exports were 515 tons, of which 338 tons went to Germany. The apparent home consumption was therefore 6,712 tons in 1883.

Hungary.—The latest official statistics available cover the year 1882. The production in that year was 672 metric tons, as against 1,036 metric tons in 1879.

Canada.—The miners of the Capelton district have continued to furnish to American sulphuric-acid makers a very large share of the pyrites used by them, and the cinders, smelted partly at the chemical works and partly at the Orford refinery, have been converted into matte from which the bulk of the copper reported under that head has been extracted. The shipments to England have dwindled to insignificant figures, the receipts at Liverpool and Swansea being estimated to contain 266 long tons fine in 1884, against 448 tons in 1883 and 347 tons in 1882.

The efforts to establish a large copper industry on the north shore of Lake Superior on deposits similar to those of the Peninsula have failed signally, although heavy amounts were invested in exploration and plant by English capitalists.

Newfoundland.—The Tilt Cove, Bett's Cove, and Little Bay mines have evidently, if the falling off in the shipments to Great Britain are a criterion of their status, seriously felt the effect of the decline in values. In 1884 the receipts in Liverpool and Swansea were only 224 long tons fine, as compared with 1,185 long tons in 1883 and 1,362 tons in 1882. It should be stated, however, that a large shipment of 1,000 tons of 4 to 5 per cent. ore was made to this country in 1884.

Mexico.—American capitalists have become interested in a number of copper mines, particularly in the northern part of the country, and a number of plants have been put up without as yet producing notable quantities of metal. Some of the copper has come to American refining works, but the bulk of the ores and furnace products go to Great Britain, where the receipts were 291 long tons in 1884 compared with 489 long tons in 1883 and 372 long tons in 1882. Reports from reliable sources, however, indicate that deposits of exceptional magnitude exist in Lower California, near Cape Saint Lucas, accessible by sea, so that smelting works commanding a comparatively cheap supply of English coke would be enabled by working the high grade ores to become formidable contributors to the world's supply. It has been stated that the control of this property has passed from the hands of a Guaymas firm to a syndicate of French capitalists.

Venezuela.—For some years upward of 3,000 tons of copper annually have been marketed by the Quebrada Railway, Land, and Copper Company, an English company, a consolidation of formerly independent railroad and mining companies. It works a pyrites deposit, shipping the higher grade of ores and smelting the lower grade to matte for export. The applicability of the Rio Tinto wet methods to the treatment of the poorer ores has been investigated, but as yet the results have not been published. In 1882 the sales amounted to 3,415 long tons, increased in 1883 to 3,589 long tons. The latter product, in spite of the higher prices prevailing in 1883, failed to yield a profit, and the Quebrada mines may be placed among those which will be unable to compete at current figures. The receipts from Venezuela in 1884, however, showed no material decline, being placed at 3,675 long tons.

THE MINES AND REDUCTION WORKS OF BUTTE CITY, MONTANA.

By E. D. Peters, Jr.

THE MINES.

The high position that Butte City, Montana, now occupies as a producer of the valuable metals, standing second only to Lake Superior in its shipments of copper, and ranking among the first in its production of silver, has naturally attracted much attention among those interested in mines and metals. Several valuable articles have appeared in certain technical journals descriptive of some of the individual mines of this district, but I have yet to learn of the publication of any general descriptive paper, giving an idea of the geology of the camp, the peculiarities of its veins, and a trustworthy description of the methods employed for the treatment of its ores. The object of the present paper is to partially fill this gap; and if it is noticed that less attention is paid to the three or four great silver mines and mills that first gave Butte its celebrity than their importance would seem to warrant, it is because exactly this subject, to the exclusion of nearly all other interests, has received particular attention in the articles already mentioned, and because full accounts of the Alice, Lexington, and Moulton mines and mills are accessible to all.

The district.—That portion of the Butte camp which to the present time alone possesses especial interest to the miner may be mostly inclosed within the lines of a rectangle having a length of 2½ miles and a breadth of 1 mile, roughly speaking. This rectangle extends from Yankee Doodle gulch on the east to a point somewhat below the Boston and Colorado Concentrator on the west, and from the northern extremity of Walkerville district on the north to the extension of Park street on the south. Within these narrow limits are the three great silver mines already mentioned, the Anaconda, Parrot, Colusa, Bell, Liquidator, Gagnon, Saint Lawrence, Mountain View, Clear Grit, and dozens of other noted and productive mines, besides the whole system of silver-bearing manganese leads, and an almost indefinite number of veins already discovered, and more or less developed. Outside this small area, though there is no lack of prospects, some of which promise exceedingly well, I do not know of a single property which can yet (autumn of 1884) be classed among the paying mines.

Geological.—The geology of this rich metalliferous rectangle is at first glance exceedingly simple, consisting apparently solely of a coarse-grained and very hard granite, containing an undue proportion of quartz and mica, and less feldspar than is usual. On closer inspection it will be noticed that while in the eastern or cupriferous portion of the area mentioned the granite is exceedingly coarse grained and shows no sign of stratification, in the western or argentiferous division the mica predominates, and is arranged to a greater or less extent in parallel layers, approaching a mica schist. So far as my observations extend, the feldspar is entirely orthoclase, while both the brown and white varieties of mica (biotite and muscovite) occur, though in widely varying proportions at different points. There is a regular and well-marked connection between the structure of the granite and the contents of the fissures by which it is traversed; but neither the scope of this paper nor the observations at my disposal warrant any further speculation in this direction.

The miners universally speak of porphyry dikes, which run parallel with, and usually form the walls of, all the large copper veins that have been opened to any great depth. But in every instance where I have been able to examine the matter personally the so-called "porphyry dike" has been found to be merely an altered granite, in which the solutions flowing through the vein and saturating its walls to a considerable distance on either side have apparently decomposed the feldspar and frequently the mica, leaving the fragments of quartz which once helped to form the granite surrounded by, and embedded in, the silicate of alumina which now represents the feldspar, and altogether yielding a belt of rock parallel to the vein and bearing a remarkable resemblance to porphyry. In other cases the results of decomposition have been such that the altered granite resembles a fireclay containing angular fragments of quartz. This is often used where refractory material is required, and though not equal to a good fireclay will still stand a very high temperature without melting. Of two bricks made from this decomposed granite, one (the smaller) was placed in a white-hot muffle for several hours, while the larger one was used as a support under the end of the same muffle for several weeks—a severe test even for a good firebrick—and both were removed practically unaltered.

But on the bridge wall of a reverberatory smelting furnace a few hours sufficed to melt it into a pasty mass, while a Golden City firebrick showed only a slight rounding of the thinnest edges. I have given these details, hoping that they may undeceive certain inhabitants of Butte who are holding these leads of decomposed granite under the mistaken impression that they possess a great future value.

Classification of the veins.—As even an imperfect attempt at classification is preferable to complete chaos, the Butte veins may be divided, for convenience of description, into two great classes:

1. Copper veins, carrying more or less silver.
2. Silver veins, carrying little or no copper, and having a manganese gangue.

One or two of the most noted Butte mines, the Gagnon and its extensions, cannot be classed under either of these divisions, and must be described separately.

The first group embraces the Anaconda, Parrot, Liquidator, Bell, etc. The second group includes the Alice, Lexington, Moulton, and many others of less note, but exhibiting the same surface characteristics. While both the valuable minerals and gangue of these two systems of veins are quite different, and while each group is geographically tolerably distinct from the other, they still possess many features in common. For instance, they all traverse a granite formation; they are nearly all accompanied by the zones of decomposed country rock described above; they nearly all pitch either perpendicularly or at a very steep angle; though they are doubtless true fissure veins, they lack entirely, so far as my observation extends, that distinct demarkation between vein and country which is in some districts so very striking; nor do any of them possess the clay gouge on either foot or hanging wall, which is sometimes of such an assistance to the miner when drifting on the course of the vein. They all, without exception, contain copper and silver, though in widely varying proportions, and most of them contain traces of gold.

The copper veins.—These usually appear on the surface as wide bands of quartzose rock, much decomposed and heavily stained with oxides of iron. Carbonates and oxides of copper mostly appear only as stains, so that, as will be seen, there is little indication of the immense value below. This surface ore invariably carries silver, generally in a free-milling condition, and in most of the larger veins in sufficient quantities to pay for treatment. In fact, nearly all the mines that are now considered distinctly as copper leads, such as the Anaconda, Parrot, etc., were first treated exclusively as silver properties—assaying from 10 to 60 ounces per ton, and averaging perhaps 20 ounces. This surface ore continues until the water line is reached, at a depth of from 50 to 130 feet, when, without warning, it changes at once into the base ores that now constitute the principal value of these leads. These ores are somewhat indefinite minerals, resembling copper glance, erubescite, peacock copper, and some irregular compounds of copper, iron, and sulphur. Neither the Butte copper glance nor erubescite agrees exactly, either in its physical or chemical characteristics, with the mineralogical description of these compounds, and a careful study of them would amply repay any skilled mineralogist. A small quantity of copper pyrites is also found, but though most of the copper ores are slightly arsenical, I have as yet seen nothing resembling fahlerz (gray copper ore). I agree with Mr. William Semmons in considering enargite to be the principal source of arsenic.

The condition in which the silver occurs in the free-milling ore is yet undetermined. The miners speak confidently of large amounts of chlorides, bromides, "carbonates," and even "oxides" of silver, and it is certainly the prevailing impression that most of the precious metal occurs in these rare compounds; but aside from small quantities of chloride of silver, I have been unable, either by chemical or physical examination, to detect any of the salts of silver referred to, nor have I found any local chemist who has been more successful. Below the water line the silver is principally contained in the erubescite and copper glance, very small assays being obtained from either pyrite or chalcopyrite. But I am also inclined to think that it occurs largely as a thin coating of sulphide on the cleavage planes of the peacock ore; as frequently, on breaking open such ore masses, the whole plane is found plated with a thin coating of native silver, which has evidently resulted from the reduction of argentic sulphide.

Perhaps the next most noticeable feature of the Butte copper veins is their great size and remarkable continuity. It is not at all uncommon to find the vein 30 feet in width for several hundred feet of its course, and filled with ore from wall to wall for its entire distance. I am now referring to second-class ore, suitable for concentrating, and assaying from 5 to 18 per cent. of copper. This grade of ore forms the principal value of the camp, occurring with such regularity and in such large bodies that mining is robbed of most of its risks. The first-class ore is distributed with little regard for regularity, in chutes, chimneys, pockets, kidneys, and every other conceivable form, and on an average may constitute one-tenth of the entire ore. Where the various mines differ so greatly in both strength and quality, it is difficult to give average figures with any approach to accuracy, but I think I am well within bounds in placing the average width of pay ore in the principal copper veins at 7 feet. The Anaconda is the widest of any yet opened, averaging certainly over 12 feet of profitable ore, and in many places widening to 30 and 40 feet for a great distance. In order to show the unusual depth which this erubescite ore attains in this district, before being replaced by the poorer yellow sulphides which doubtless form the normal unaltered ore of these veins, I will mention here that the 300-foot level of the Anaconda shows no diminution in the richness of the ore. (If I remember rightly, the deepest point in Chili at which these peacock ores have held was in the celebrated Piqué mine at a depth of about 800 feet, at which point the rich erubescite ores were replaced by yellow sulphides, averaging about 7 per cent. It seems probable that Butte may count on a still greater depth of rich ores.) The Parrot and Liquidator also carry exceedingly strong ore bodies, and of remarkable continuity.

For convenience of more minute description, the copper veins may be classed in two subdivisions:

1. Those in which the copper is found mainly in the shape of copper glance, or a mineral greatly resembling copper glance, though not containing quite the amount of copper called for by the formula CuS.

2. Those veins in which erubescite is the principal copper-bearing mineral.

The Anaconda and Liquidator are good examples of the first division, having, as a rule, a gangue rock of quartz and decomposed feldspar, and carrying scarcely any other ore, except copper glance and a small percentage of pyrite, thus yielding concentrates of a very high grade; while the first-class ore, which is now sacked and shipped to Europe, consists entirely of high grade, forming, both as regards quality and quantity, perhaps the finest shipping product in the country. The Liquidator and Colusa also furnish a very large amount of second-class ore, which is sufficiently free from pyrite to concentrate to 30 per cent. and over, though in the lower levels, as might be expected, the proportion of pyrite has decidedly increased.

The second division is represented in its most perfect type by the great Parrot vein and its eastern extension, and for some 2,000 feet carries an almost uninterrupted ore chute so far as explored. It is characterized by its high percentage of erubescite, carrying nearly its entire copper contents in the shape of that mineral, the occurrence of copper pyrites being rare and unimportant. The first-class ore can be easily selected to 30 per cent., while nearly the entire vein, from 5 to 30 feet in width, is suitable for concentration, sampling 12 per cent. as the average of three years' working. But it is not alone as a copper vein that the value of the Parrot must be estimated; it is also a silver-bearing lead of great value, carrying on an average two-thirds of an ounce of silver to each per cent. of copper, while above the water line, to a depth of 80 feet or more, there is a fine body of free-milling silver ore of great strength and value left untouched.

The value of nearly all these veins is considerably enhanced by the fact that to a depth of 800 feet no serious amount of water has been encountered, and that where proper appliances have been introduced, natural ventilation suffices to keep the air in a perfectly good condition. The country rock is also of such a quality that no difficulties are encountered in timbering, beyond such as naturally arise in working out an ore body of 30 to 40 feet in width, and which supplies no barren material for filling.

The silver veins.—The second great division of veins includes the manganese-silver group, and presents certain unique features. In speaking of the formation and mineralogical characteristics of these leads, I am fortified by the opinion of Prof. Alvin Weisbach, professor of mineralogy at the Freiberg School of Mines, who examined some of the mines and ores of this district with me. These manganese veins all lie in a small and strictly circumscribed territory, to the west and north of the copper group, and most of them crop boldly to the surface, forming often large comb-like ridges of brown and black rock, stained principally by the oxides of iron and manganese, and showing every evidence of thorough decomposition. On closer examination, these croppings are found to consist of a more or less prominent quartz skeleton, heavily charged with the minerals of manganese known as pyrolusite, psilomelane, braunite, and wad. They occur in the order mentioned as regards frequency of appearance, the latter being comparatively rare. They are almost exclusively in a massive or amorphous condition; crystals, or even evidences of crystallization, being almost unknown. But as interesting as the occurrence of these extensive masses of oxide of manganese in a district otherwise filled with sulphides may be to the geologist, they are still more interesting to the miner, from the fact that they are, without exception, argentiferous, though varying from 3 or 4 to several hundred ounces per ton. The average value of the selected ore extracted from these leads may be about 20 ounces, but in what chemical condition the silver occurs I am unable to say positively, though I can state with certainty that it does not occur either as a bromide or iodide, as seems to be the popular opinion, nor in my own investigations have I been able to satisfy myself of the occurrence of chloride, except in traces.

The percentage of manganese varies as greatly as does the silver value, and unfortunately stands in an inverse ratio to it; the massive ores of manganese seldom containing more than a few ounces of silver, while the ores rich in silver have, as a rule, a gangue of quartz rather than of manganese. This is a serious drawback in smelting, for as quartz predominates in nearly all the Butte ores, an addition of manganese would be a most welcome flux. A few analyses of these ores will illustrate the above statements.

A sample of surface ore from the Nile mine, which represents fairly the better class of manganese ores, was found to contain:

Analysis of manganese-silver ore—No. 1.

	Per cent.
Oxides of manganese	47.[illegible]
Oxides of iron	12.[illegible]
Silica	34.[illegible]
Alumina	3.70
Silver ([illegible] ounces)	.11
Sulphur	Trace.
Moisture and loss	1.[illegible]
	100.00

A massive piece of manganese ore (a mixture of braunite and psilomelane) from unknown mine contained:

Analysis of manganese-silver ore—No. 2.

	Per cent.
Oxides of manganese	88.40
Oxides of iron	1.20
Silica	8.60
Silver (9 ounces)	.03
Moisture and loss	1.77
	100.00

A mill sample of a 20-ton lot of ore from a noted manganese mine near Butte, stoped at a depth of about 40 feet from the surface, contained:

Analysis of manganese-silver ore—No. 3.

	Per cent.
Oxides of manganese	21.000
Oxides of iron	7.700
Silica	66.400
Alumina	2.400
Silver (80 ounces)	.275
Moisture and loss	2.225
	100.000

These analyses have been selected as types of the principal varieties of manganese ores, and show plainly the decrease of manganese as the silver contents increase.

In describing the first division, or copper leads, of this district, I have shown how suddenly the vein contents change at the water line, from an almost free-milling silver ore without any copper to a massive sulphureted base-metal ore, rich in copper and generally poor in silver. The transition is at least equally striking in the second or manganese-silver division. Here again the water line constitutes the boundary, and the decomposed masses of brown, yellow, and black oxides of iron and manganese change almost instantaneously into a gangue of silicate and carbonate of manganese (the former greatly predominating), with a large admixture of quartz, the whole being specked and threaded with minute granules and veinlets of zincblende, pyrite, chalcopyrite, and galena—the two latter materials occurring in very subordinate quantities, and the entire amount of sulphureted minerals seldom exceeding 5 per cent. of the ore, and much more frequently falling below 3 per cent., though in the Lexington and Alice mines bodies of very base ore are encountered.

The silicate and carbonate of manganese have their characteristic pink color, and contrast very beautifully with the white quartz, but although the ore usually retains its full silver value, as compared with the upper decomposed portion of the vein, it has lost its worth as a flux in smelting, and, as a rule, is only fit for milling. I am at a loss to say in what condition the silver occurs in this ore. Owing to the high assays that I have often obtained from specimens which showed only the most minute specks of sulphide minerals, I have been led to search most carefully for some of the noble silver minerals, such as silver glance, brittle silver, etc., but entirely without success; nor could the experienced eye of Professor Weisbach detect any trace of them in the various specimens submitted to him. Chemical tests also disprove the existence of silver chloride, so that as yet I am unable to explain the matter. The popular opinion is that the silver is contained in the zincblende and pyrite, but when the entire weight of those minerals forms less than 2 per cent. of a given sample that assays 1.5 per cent. in silver, it is difficult to reconcile that theory with the facts of the case. This is a very interesting and important subject for future research.

Although not generally so considered, the great mines that have given Butte its celebrity as a silver district, namely the Lexington, Alice, Moulton, etc., belong strictly to this manganese-silver group, though their water line being comparatively near the surface, the oxidized zone continues but to a slight depth. They still show plenty of "pink manganese," as the carbonate and silicate of manganese are indefinitely termed by the miners, but on the whole quartz predominates decidedly and zincblende and pyrite occur in much larger proportion than in most other mines of this group. I need hardly say that this necessitates a thorough chloridizing roasting prior to amalgamation, and in fact none of the manganese ores that occur below the water line can be treated raw with any satisfactory results.

At present, with the exception of the great mines already mentioned, the manganese-silver belt is adding but little to the production of Butte. A few hundred tons per month of heavy manganese ore, assaying from 15 to 50 ounces of silver, are mined and sold to the Boston and Colorado Smelting Works, and a much smaller quantity of more quartzose ores are treated in custom mills.

Few, if any, of these mines—always with the exceptions above mentioned—are worked below the water line, and they are mostly too quartzose and too poor in silver to pay for smelting, nor can many of them stand the losses and heavy milling charges incidental to amalgamation. In time, with cheaper fuel and labor, I think a small proportion of them may prove of some value, but not before they come into the hands of companies willing and able to erect mills on a very large scale and look to small profits per ton on large amounts of ore for their reward. At present most of them are in the hands of poor men who can do nothing with them themselves, but who hold them at prices that are virtually prohibitory to capitalists.

The Gagnon.—In my attempted classification of the Butte mines I have encountered one difficulty in the shape of the Gagnon mine, which is so different from either class described as to be positively unique, and it demands at least a few words to itself. As regards geographical position, it is assumed, and I think correctly, to be the western extension of the great Parrot lode, and apparently while trying to hold its own as a copper lode it has (together with its extensions, the Original and the Butte Original) been so powerfully influenced by the conditions which governed the formation and filling of the silver group into which it extends that it has assumed a mixed character, intermediate between the two divisions, and yet possessing certain characteristics of its own. While its percentage of copper is much lower than that of any of the true copper veins, its contents in silver are for the most part higher than any but the very richest of the silver group. Its gangue is principally quartz, and its chief ore an argentiferous zincblende, though the compounds of copper which occur in the Gagnon also carry a considerable quantity of silver, as does the iron pyrites, which occurs abundantly.

The ore occurs in very large and strong pay chutes, and, so far as exploration has yet gone, certainly does not improve in depth. The best ore, both in quantity and quality, was found near the surface, several hundred feet above the present workings, but I am credibly informed that it is now rapidly improving in the deeper levels, and that every indication is present of other large bodies of rich ore in near proximity.

The Butte minerals.—A list of minerals from this mining district, determined by myself, is appended. Those marked with exclamation points (!!) are rare in this place.

Graphite!, native gold, native silver, argentite, cerargyrite, chalcocite, chalcopyrite, erubescite, cuprite, malachite, azurite, chrysocolla, galenite, anglesite, cerussite, sphalerite, rutile, molybdenite, pyrite, pyrrhotite, enargite, tetrahedrite, arsenopyrite!, pyromorphite!, hematite, magnetite, limonite, siderite, pyrolusite, psilomelane, braunite, wad, manganite, rhodonite, rhodochrosite, calcite, barite, witherite!, quartz, jasper, pyroxene, tremolite, actinolite!, hornblende, garnet, epidote, biotite, muscovite, andalusite, orthoclase, oligoclase, cyanite.

THE REDUCTION WORKS.

Methods of treatment.—The foregoing classification of the Butte mines may be partially adapted to the metallurgical process employed for the reduction of the ores. But as differing conditions may suggest different methods for the treatment of the same ore, I find it convenient to to divide the processes here in operation into five classes:

1. Raw amalgamation of silver ores.
2. Chloridizing-roasting and amalgamation of silver ores.
3. Smelting of silver ores in reverberatory furnaces, with the addition of sufficient copper ore to form a highly argentiferous matte.
4. Smelting of copper ores in reverberatory furnaces.
5. Smelting of copper ores in blast furnaces.

It will be noticed that the classes numbered 3 and 4 are nearly identical metallurgically, as in both cases the product is a copper matte, in which whatever silver happens to be in the ore is concentrated, the quantity of the precious metal being in any case so small as to have no effect on the method employed, metallurgically speaking, however important it may be from a commercial standpoint. But the quality of ore treated is so different in the two cases referred to, and the employment of oxide of manganese almost exclusively as a flux for silica in No. 3 is so interesting and so rare, as to demand a separate notice.

In Nos. 3, 4, and 5 a certain proportion of the ore is prepared mechanically for the furnace by wet concentration, and as this is the step that naturally follows mining, its description is in place here.

Concentration.—There are four separate concentration works in Butte, having an aggregate capacity of about 300 tons of raw ore daily, and at least three more already about completed or in progress of erection, which are estimated to treat an additional 350 tons per day. These, of course, are exclusive of the great works at Anaconda, which are expected to concentrate 500 tons daily, and with sufficient furnace capacity to smelt the concentrates produced.

In describing both smelters and concentrators I shall naturally make most use of such facts as are personally familiar to me as the metallurgist of what may perhaps be considered the representative copper works of the district. I trust this may be considered a sufficient excuse for any statements that may not apply strictly to all the establishments in the class referred to.

Our ores of copper being mostly erubescite and copper glance, have a sufficient specific gravity (5), as compared with their quartz gangue (2.5), to permit of a tolerably perfect separation, but the unfortunate tendency of these high grade copper minerals to form slimes, combined with their very high percentage in copper, necessitates a heavy loss in concentration, especially in the fine tailings, and one that can be only partially remedied by extensive slime pits, as the fine copper dust once brought in contact with water settles with extreme difficulty, and long remains floating on the surface of even stagnant water.

Another serious drawback in most of the mines is the occurrence of pyrite, so intimately mixed with the ore as to defy handpicking. Having nearly the same specific gravity as the copper ore, and a less tendency to form slimes, it concentrates even more perfectly than the valuable constituents, and positively prevents the production of a concentrate containing over from 20 to 30 per cent. of copper, except in the case of the Anaconda and one or two equally fortunate mines, where the proportion of pyrite is so small as to permit of a product carrying from 45 to 50 per cent.

I have made a series of careful experiments, with a view to the discovery of some means by which the iron and copper minerals might be mechanically separated. Finding that a slight discrepancy in specific gravity exists between erubescite and pyrite, I hoped to obtain, at least on the first sieve of the jig, a product high in copper; but discovered, after repeated trials, that there was just about enough difference in the form of the grains of each mineral, owing to their different cleavage planes (the heavier mineral consisting mostly of long, flat grains, while the lighter breaks rather into solid cubes), to effectually neutralize any advantage that their difference in gravity might offer. Failing in this trial the next most promising idea seemed to lie in the fact that the thorough calcination of iron pyrites, as practiced with us, yields principally a highly magnetic oxide of iron, which quality I hoped to take advantage of to separate it from the oxide of copper. But on trial I found that erubescite (a compound of iron, copper, and sulphur) also yields after calcination a highly magnetic powder, and that the result of passing a magnet through our calcined concentrates was to remove everything except what small percentage of silica was present. Whether this plan might prove more successful on a mixture of pyrites and copper glance—which latter mineral does not become magnetic on roasting—I have not had the opportunity of determining.

While the concentration works now in operation in Butte, as well as those in process of erection, are by no means model establishments, they still do very good average work, and are perhaps quite as well adapted to the peculiar conditions as more elaborate works. The loss of copper in the tailings is considerable, and under eastern conditions could not be tolerated; but it must be considered that in Butte the ore is the cheapest thing we have, while fuel, labor, and machinery are extremely expensive, and that the copper contained in the ore has cost so little to mine that it does not acquire any considerable value until a certain amount of labor has been expended on it.

While I do not deny that a more perfect sizing, a graded system of crushing, and a more systematic effort to concentrate the finer classes of ore might even now prove remunerative, I doubt very much if it would pay expenses to greatly extend the present system of slime treatment, in which department the principal losses occur. I can, however, assert positively that at least one of the concentrating mills in course of erection is so arranged as to carry out to a considerable extent the improvements just discussed.

The general system of working is to crush the ore first through a coarse and then a finer rock breaker, a $\frac{3}{4}$-inch mesh screen being interposed between the two breakers to remove such ore as is already sufficiently fine for the first set of rolls, to which all the ore from the breakers is elevated, and which are usually set to yield a product not larger than $\frac{3}{8}$-inch. After passing one or two sets of rolls, the ore is delivered to a trommel-system, having a mesh of $\frac{3}{8}$ and $\frac{1}{24}$ inch for the two extremes, and being four or, better, five in number. Each size of ore goes to a separate automatic jig, or pair of jigs, which are in most cases arranged to work through a bed of mineral of the next larger size, only the coarser sizes having a side discharge. The jigs have from three to four sieves, and are all, I believe, side-piston hydraulic jigs. A modification of the old Clausthal discharge is used to remove the concentrates in most cases, though the cap and tube has also some advocates.

The product of the first sieve should be always clean enough for smelting, while that of the second and third sieves is either recrushed or fed back into the machine. The pulp which passes through the finest sieve, $\frac{1}{16}$-inch, is either carried to the slime pits or fed direct to Frue vanners or tables; or, as in the Parrot mill, separated into equal-falling sizes by pointed boxes, and the product of each separator worked upon a separate vanner, which is by far the most perfect method.

The slimes which flow over the pointed boxes are caught in sumps or labyrinths, and either thrown away or used as they are. Being very siliceous, and yet often containing too much copper to lose, they form a very disagreeable product, and one that is apt to accumulate on the hands of the metallurgist.

I think the point of sufficient importance to mention a plan that I have adopted at the Parrot works, and which enables us to work up most of our slimes at virtually no expense. Every one accustomed to the management of reverberatory furnaces knows the large amount of sticky loam and clay that is required to lute up the side door of the furnace, especially after the jambs are well burned out, so that a wide crack on each side of the door has to be thus filled. Assuming a furnace to smelt five charges a day, thus necessitating the luting up of the side door an equal number of times, and allowing only 50 pounds dry clay to each luting—and this is far below the average on old furnaces—it will be readily seen that where from six to a dozen furnaces are in operation the amount of clay used reaches a surprising figure. Now, on taking down the side door, all this clay falls down upon the fresh charge, which is piled just under the door, and eventually finds its way into the furnace, where it adds a serious amount of barren quartz to a charge already probably too siliceous. A careful trial proved that the slimes would answer the same purpose as the clay; and now, instead of smelting a ton or more per day of barren loam, we have replaced it with an equally satisfactory material, carrying 10 per cent. or more of copper.

To return to the subject of concentration. It is impossible to furnish any figures that shall apply to the different mills with any degree of accuracy, but in order to give a general idea of the results obtained from those ores carrying a high percentage of iron pyrites, which includes the greater part of the ores at present submitted to concentration, I will submit the following figures as a reasonable average:

Results of concentration.

	Per cent.
Original amount of copper in the ore	12
Assay of concentrates from jigs	21½
Assay of concentrates from vanners	22
Assay of slimes saved	9 to 13
Assay of slimes lost (forming a very small percentage of the total ore)	6½
Assay of tailings (excepting slimes)	3½

Degree of concentration, 2.1 tons into 1.

The works now building will give considerably better results, the points principally selected for improvement being the recrushing and reworking of all the middlings and tailings from the coarser jigs; a great increase in the capacity and efficiency of the sizing apparatus, as well as a corrected scale of sizes for the trommels; the substitution of hydraulic separators of ample capacity for the finest trommels, thus enabling the slime jigs to work a product consisting of equal-falling instead of equal-sized grains, by which the amount of feed water is lessened, and the capacity of the machine greatly increased; the substitution of an ample number of sideshaking tables for an insufficient number of vanners, and a thorough sorting of the pulp by hydraulic separators before feeding to the tables. These improvements, supplemented by a more systematic and extensive effort to save such slimes as are worth smelting, are expected to considerably increase the efficiency of the works.

Want of space forbids any greater amplification of this subject; but I think enough has been said to show the mining public that the science of concentration is by no means neglected in Montana, and to convince the proprietors of patent concentrating machines that the tailing beds now forming below the Butte concentrators are no such mines of wealth as they have been considered by several persons of this description, but who have been speedily undeceived on trial.

For the sake of completeness, I must mention the concentrator belonging to the Montana branch of the Boston and Colorado Company, which I am informed runs a large portion of the time on the oxidized manganese-silver ores mentioned in the first section of this paper. It is reported that, while some of these ores are too heavy in manganese to render concentration applicable, and while others carry so much of their silver contents in the quartz gangue as to cause an unreasonable loss, the ores found in certain mines are extremely suitable for this purpose, and admit of the production of a concentrate high in manganese, and in which most of the silver is retained. This forms a most welcome addition to an establishment that labors under the disadvantage of an overwhelming amount of silica in its smelting charges.

Amalgamation.—I shall dispose of the first and second divisions of the Butte metallurgical establishments in very few words, as the proccesses employed are so universally known, and these especial works, namely, the Lexington, Alice, Moulton, Silver Bow, and other mills, have been so thoroughly written up as to render any description that I could furnish entirely superfluous.

The Dexter mill is, I believe, the only one in which raw amalgamation is now practiced, and the ores it is treating are becoming so base as depth is gained that the percentage of silver extracted is far from satisfactory. The tailings show a considerable quantity of argentiferous carbonate of lead, and are now being concentrated, yielding a product assaying in lead slightly above the percentage called for by the formula of that mineral, and from 30 to 40 ounces of silver per ton. So far as is yet known, a very small proportion of the silver ores of this county are suitable for raw amalgamation.

The second division includes the Alice, Lexington, and several other mills, which practice a chloridizing roasting followed by pan-amalgamation. The Stetefeldt, Howell, and Brückner roasting furnaces are all represented in this district, and, so far as I know, the results are good, and present nothing of a particularly unique or interesting character.

The enormous charges levied by the Utah and Northern railroad for transporting the salt, which is so necessary in silver milling, from Ogden to this point ($20 per ton, while coal is brought nearly double the distance for about $6 and coke is transported from Pennsylvania for about $18), effectually block any attempt to treat the low grade silver ores, which occur so abundantly in this district, and which, if it were not for this grasping policy on the part of the railroads, would possess a certain value, though they are of too low a grade to ever yield a profit except to those who are able to work them on a very large scale.

Smelting of silver and copper ores in reverberatories to a rich matte.—The third method employed in Butte is the smelting of silver ores with sufficient sulphureted copper ores to form a copper matte, small in amount, but very rich in silver. This is produced only at the works of the Colorado and Montana Smelting Company, and is shipped for further treatment to the parent establishment at Argo, Colorado. My knowledge of this smelter is limited to hearsay, and to my own general acquaintance with the process employed. As the chief object of these works is to concentrate the valuable contents of a great many tons of ore into a very few tons of matte, it will be readily seen that the two substances to be avoided in the furnace mixture are sulphur and copper. Fortunately, most of the silver ores carry very little base metal, and are either surface ores, entirely free from sulphur and copper, or so-called "dry" ores carrying only a small percentage of zinc or lead, and mere traces of copper. Certain varieties of these ores carry sufficient iron pyrites and zincblende to demand a calcination previous to smelting, but by far the larger part can be fused raw. These true silver ores are mixed at the furnace with copper-bearing silver ores from the Gagnon and other mines, in which, however, the percentage of copper is low, and the sulphur is mostly eliminated by an oxidising roasting. It will be noticed that all the ores thus far mentioned consist principally of silica, with the exception of such argentiferous ores as come from the manganese district, and a careful examination even of these so-called "fluxing ores" will show that the larger proportion of even these ores carry far too much silica and too little oxide of manganese and iron to form an easily fusible slag by themselves, much less to assist in fluxing other still more siliceous ores. Judging by eye, I should say that the furnace mixture, as made at these works, contains a higher percentage of silica than at any other similar smelter in the United States. The charge is far too siliceous to admit of all the quartz being fused and dissolved in the slag. On the contrary, the upper layer of each pig of scoria, to a depth of several inches, will be found to consist of unaltered fragments of quartz, cemented together by a glassy and extremely siliceous slag of a very low specific gravity, and consisting, as far as I can judge, of a mixture of bi- and tri-silicates of manganese, iron, and lime, the latter being added as a flux. This method of smelting is technically called "soaking," as the metallic contents of each fragment of quartz are soaked out by exposure to intense heat and long contact with the layer of molten matte which has collected in the hearth of the reverberatory furnace. As unsatisfactory as it may seem to such metallurgists as are only accustomed to the homogeneous and thoroughly molten slag of the blast furnace, this procedure yields most excellent results, as I know by personal experience. The metal is almost completely extracted, and the saving of basic flux is simply enormous. I append the silica determination of a fragment of this slag, picked up on the railroad track, where it is used to ballast the roadbed. It came from the upper or more siliceous layer of the slag block, and closely resembled a certain basaltic porphyry which occurs on the slopes of the curious volcanic butte west of Bernalillo, New Mexico, and known all over that country by the name of El Cabezon (Big Head).

Analysis of reverberatory slag ("soaked").

	Per cent.
Total silica	86
Silica in unmelted fragments Silica in the fused portion of slag	24.6 64.2
	88.8

Discrepancy, 2.8 per cent.

I am informed that wood alone is used as fuel in the five reverberatories which are employed in producing this silver matte. Also that a charge of 3 tons is usually smelted in six and one-half hours, though frequently much more time is necessary to fuse a charge containing an undue proportion of silica. It is also reported that each furnace is tapped once weekly, yielding about 3 tons of matte, varying greatly in value as the ores treated are richer or poorer. A sample assayed under my supervision contained 53 per cent. copper, 815 ounces silver, and 2 ounces in gold per ton. Judging from the figures already given it would seem that about 20 to 25 tons of ore are concentrated into 1 ton of matte. Much of the silver ore smelted at these works could be far more advantageously treated by chloridizing roasting and amalgamation, or by leaching.

Smelting true copper ores in reverberatories.—The fourth division of the Butte metallurgical works, the smelting of true copper ores in reverberatory furnaces, includes three important establishments, named in the order of their production: The Parrot Silver and Copper Company, the Montana Copper Company, and those furnaces (soon to be increased in number) running on ore from Clark's Colusa mine. Their product probably exceeds in value that of the other four divisions.

In cases in which I am doubtful, the statements here made must be taken as referring to those works with which I am personally most familiar. Private interests forbid as accurate and detailed description of the works and statement of expenses as I should be glad to furnish.

The ore, as it is broken in the mine, is divided on the spot into at least two classes—first-class ore, assaying from 20 per cent. upwards, which is ready for smelting, and second-class ore, assaying from 10 to 18 per cent., and containing so much silliceous gangue as to render necessary a preliminary concentration. In certain of the copper glance mines a still richer class is made, which is sacked and shipped abroad. The first-class ore occurring in lumps is spalled with hammers to the size of the fist, and, after screening to remove the finest, is roasted in heaps or stalls. The heap-roasting practiced at most of the works here differs in no wise, except possibly in carelessness, from the usual method, and when carefully carried out reduces the percentage of sulphur from about 30 to 6 or 7 per cent., though this result is by no means generally obtained at certain works.

Roasting in stalls.—The stalls, used solely at the Parrot smelter, are 6 feet broad by 8 feet deep; they are inclosed on three sides, and connected with a large culvert at the back, which enters a capacious and lofty chimney. The stalls are built in long double rows, back to back, to economize material, and, although not strengthened with either tie-rods or braces, last a good many years if the surfaces of the walls next the ore are kept well protected with a coating of clay mud. At the Parrot smelter they are formed entirely of slag blocks, cast in sand molds, and weighing about 100 pounds apiece. The stalls contain about 22 tons of ore, which is dumped into them from a car running on a track over the whole line; and after being covered with fine ore, are kindled in front, and then require little or no attention till ready. The amount of wood is only about one-fifth of a cord per stall, or one-hundredth of a cord per ton of ore. If more is used, a lump of matte of greater or less size will be found near the bottom of the kiln, and the roasting will be imperfect. By the fourth day the large fragments of ore, which are built up to form the front wall of the stall, are removed, and two or three tons of well-burnt ore can be taken away without injury to the rest, great care being observed not to cut in too far toward the center, or approach too closely the line of fire, which has as yet only extended a short distance into the body of the heap. Each day a similar amount can be removed, and by the twelfth day the kiln is empty.

In comparison with heap-roasting these stalls offer the following advantages: The waste caused by rain and wind and from scattering over the ground is much less. Only about one-eighth the quantity of wood is required to roast an equal amount of ore. The labor is much less, being about as one to two and one-half. Instead of tying up valuable ore for a month or six weeks, one can begin to use it on the fifth day, and in a fortnight it is entirely finished. If properly managed there is absolutely no raw ore left over after burning in the stalls; while in heap-roasting there is always a large quantity that must be reroasted. Even the fine covering, and the ragging just below it, can be thoroughly burned in stalls if a few baskets of bark or chips are scattered over the coarse ore before the fine covering is thrown on. The sulphurous smoke from stalls is mostly discharged high in the atmosphere through a tall chimney, thus avoiding the dense fumes that come from even the smallest ore heap.

I should be glad to enumerate the disadvantages of stall-roasting as compared with burning in heaps; but after a long experience with both methods, I have nothing to say on the other side, except that in case one has to deal with an ore carrying a very high percentage of iron pyrites, it is easier to prevent matting in heaps than in stalls.

To prevent disappointment, in case my testimony should give rise to experiments on the part of metallurgists who desire to escape the drawbacks of heap-roasting, I must particularly insist on the importance of having a strong draft, which, of course, presupposes a large flue, and a chimney of sufficient area and height. For a battery of thirty stalls, arranged in a double row, back to back, with a flue extending between the two lines, the main culvert should have an area of at least 4 square feet; while the chimney, with a corresponding inside area, should be carried to a height of 70 feet. With an insufficient draft, the roasting is delayed beyond all belief, and the percentage of sulphur retained in the ore after the completion of the process will be far from satisfactory. In case any considerable amount of matte is formed in the stalls, it should be broken into pieces the size of the fist, and when 50 tons or more have been accumulated, it should be roasted in heaps in very much the same manner as ore. A few necessary changes, however, must be made. The bed of wood should be thicker than for ore, and the matte pile should never be built more than 4½ feet high. It should have vents or temporary chimneys (formed by placing a couple of sticks of cordwood in a vertical position) at distances not greater than 6 feet from each other. Whatever fine stuff is formed in breaking the matte should be thrown on the heap in conjunction with the coarse, to prevent too strong a draft, and the sides of the heap should be well covered with fine roasted ore. A heap of 50 tons, prepared in this manner, will burn for six days, when the operation of "turning" may be begun, as one burning, or even two, is seldom sufficient for matte, which differs entirely from ore in this respect. It should be turned directly on to another bed of wood, prepared alongside of the original heap, taking care that the lump of molten matte which will always be found at the bottom of the heap is broken into small pieces and piled directly upon the fresh bed of wood. The second burning will take a week, and may be followed by a third if it is desirable to remove the sulphur as thoroughly as possible. The cost of each burning may be estimated at 65 cents per ton at present Butte prices of labor and fuel. If it is found profitable this roasted matte may be smelted by itself to produce a superior grade of copper, as the numerous burnings and meltings which it has undergone will have mostly eliminated the arsenic and antimony that it may have contained. As it is essential to add a certain amount of siliceous flux in smelting this material, any quartzose slags rich in copper that may be lying about the place will form the most advantageous addition, as the copper produced from them will be of the best possible quality.

In most cases the first-class ore forms but a small proportion of the material treated, and we now come to the principal ore from which the immense copper matte product of Butte is derived, namely, the concentrates obtained from the second-class ore. These usually contain about 20 per cent. copper, 30 per cent. sulphur, and 10 per cent. silica, the balance being principally iron; and they are thoroughly calcined in long furnaces, heated by wood, worked by two men on twelve-hour shifts.

Calcining furnaces.—The furnaces which have been built under my supervision are 64 feet by 16 feet outside, and have four hearths, each 14 feet long by 15 feet wide in the clear. The ore is charged from a hopper upon the hearth furthest from the grate, in quantities of 3,600 pounds, and in spite of the great length of the furnace it is at a bright red heat in two hours. Without going farther into details I will state that each furnace calcines 11 tons of ore in twenty-four hours, reducing the percentage of sulphur from 30 to below 4 per cent., and consuming exactly 2 cords of pine wood. These results are so favorable that the cost of calcination is reduced to about as low a figure as one could hope to attain with a successful mechanical furnace. Care is taken to prevent the formation of sesquioxide of iron, it being almost infusible and requiring a good deal of time and fuel before the reaction of the sulphides in the charge reduces it to a protoxide and fits it for combining with the silica present. In a blast furnace, of course, the powerful reducing atmosphere accomplishes this result at once, but in the reverberatory smelting, which we are now discussing, the point mentioned is of sufficient importance to be always borne in mind.

The concentrates are discharged through a square hole in the hearth nearest the fireplace into an iron car, and are dumped over a high wall into a paved inclosure convenient to the smelting furnaces.

Reverberatories.—Nearly all the reverberatory furnaces in Butte are constructed after the same model, and differ from the ordinary Welsh furnaces in the following particulars: The hearth is wider—11 feet and more; the grate is large, but very shallow, being little lower than the furnace hearth; the bridge is broad and low, and the roof high, so that the space between bridge and roof is much larger than usual; the arch pitches very strongly toward the skimming door, so that the vulcatory is low; but the trapezoidal hole connecting hearth with flue has an area more than 50 per cent. greater than is the usual custom; the flue is broad and high, and much better results are obtained by expanding it rapidly until it enters the stack; each furnace has its own chimney, about 55 feet in height, and with a somewhat larger area than the Welsh furnaces. An increase in height is of no advantage. Numerous and continued experiments have proved that the foregoing peculiarities are exactly suited to the fuel in use—a flaming, semi-bituminous coal from Wyoming, which seems only slightly removed from lignite. It is very light, has only a slight tendency to coke, and though ready enough to form massive clinkers if allowed, gives far better results when burned in a shallow layer, without the deep clinker bed which forms the chief peculiarity of the Welsh method of firing. With a consumption of 7 tons of this coal in 24 hours, 4¾ charges of 3½ tons each of ore can be smelted.

The slag and cleanings that are returned to the furnace are never counted in the quantity smelted. It is found advantageous to admit an additional supply of air through a series of holes in the roof over the firebridge, and as the best proportioned furnace will flame badly just after throwing a fresh fire, and especially after grating (which should be done thoroughly once in 24 hours), a hole 8 inches square must be left in the stack below the flue, by which sufficient air is admitted to cool the lining when the furnace is flaming. The average charge consists of about 60 per cent. calcined concentrates, 20 per cent. roasted first-class ore, and 20 per cent. raw ore, the screenings of the first-class ore being used for this purpose.

Works that possess no concentrator are obliged to use more or less limestone as flux, and I am informed that at few of the smelters is the calcination of the ore sufficiently thorough to admit of the addition of such a large proportion of raw ore as I have indicated.

The furnace is tapped after each third or fourth charge, yielding a matte assaying from 60 to 70 per cent. copper, and from 15 to 50 ounces in silver, according to the grade of ore. I am informed that at most of the works considerable difficulty is experienced in keeping the grade of the matte as uniform as is desired by the parties to whom it is shipped. To show that this uniformity is perfectly attainable, I append a list of successive shipments of about 15 tons each, taken from the books of the furnaces under my charge. I will also state that so far from having uniform material to work with, the ore varied both in quality and amount almost daily, and the charge seldom remained the same for three successive shifts. The time represented by these shipments was the first ten days of August, 1884.

Percentage of copper in shipments of matte from the Parrot works.

No.	Per cent.	No.	Per cent.
1	64.7	12	62.6
2	63.5	13	63.4
3	64.4	14	63.5
4	64.6	15	63.3
5	64.0	16	63.5
6	63.3	17	64.6
7	63.1	18	64.9
8	63.4	19	64.0
9	62.6	20	64.8
10	64.9	21	64.5
11	64.8	22	63.2

This list might be almost indefinitely continued.

Contrary to European experience and to the teaching of the principal mining schools of the world, the amount of copper retained in the slag is by no means excessive, considering the very high grade of the matte produced from this first smelting. I cannot answer for all the furnaces in this district, but the slag produced from those with which I am personally familiar seldom exceeds 1.25 per cent., and frequently falls to 0.9 per cent. About one-half the copper contents of the slag is present in an oxidized condition, the remainder being retained as inclosed granules of matte. The plate slag is always returned to the furnace, and all the other pigs are carefully examined and any valuable portions resmelted.

The great proportion of the slag here produced is a mixture of singulo and bisilicates of iron, very little lime or alumina being present, except when the former is added as a flux. At the Parrot works the slag approaches a singulo-silicate, while at most of the other furnaces, so far as I can judge by eye, it is considerably more siliceous. The matte is in most cases crushed in a small rockbreaker to the size of a hen's egg, sacked, and shipped, in some cases to the Baltimore or New York refiners, in others to England.

On the whole, the reverberatory practice in this district is fairly satisfactory and economical; though, as I have found by experience, constant attention to the size and condition of the furnace flues and other comparatively trifling points is rewarded by results entirely out of proportion to the labor expended.

With all varieties of fuel, a constant watchfulness and correction of the ever changing proportions of the more important parts of a reverberatory furnace (such as the bridge, flue, vulcatory, etc.) is demanded, but I have never yet met a variety of coal where the results obtained seem to depend so greatly on these slight and apparently trifling points, nor where the furnaces were so sensitive to minute alterations. I have had a furnace suddenly fall off from bringing its charge in five hours to requiring eight hours for the same operation, and the changing the size of the flue by the addition or removal of an inch of material, again restore the five-hour period. And as such circumstances are the rule and not the exception, it follows that a very little carelessness or inattention on the part of the metallurgist may cause almost unlimited loss to the works. I have particularly emphasized this matter, as I feel certain, from my own observation, that it is not in all cases understood or at least not acted upon.

I have endeavored to make this point still more noticeable by reducing certain results, which have occurred under my own observation, to actual figures. Knowing the exact profit to the company on each pound of copper produced under ordinary circumstances, I have found by calculation that by increasing the area of the flue of a certain furnace by 10 square inches, it produces a greater profit daily of $57.30, and adding to this the amount of fuel saved by doing good work instead of poor, the total difference amounts to $68.77. Assuming that six furnaces (the average number in the principal works) have all been built on the same incorrect model, the sum advances to $412.62 daily, or $150,606.30 per year. While this state of affairs might not very probably occur, the calculation is far from being a fanciful one, and I hope may forcibly illustrate the immense importance of forcing every smelting furnace to do the best possible work of which it is capable.

Repairs.—While I am on the subject of economizing in furnace work, I may properly mention the immense waste of money involved in unnecessary delays in making repairs. That frequent and extensive repairs must be made on reverberatory furnaces is an unfortunate fact, but every possible means should be employed to lessen the evil, by shortening the time during which the furnace is idle. Every moment of delay adds heavily to the expense, not only in the item of wages, which includes those of the masons, helpers, laborers, and the whole gang of men belonging to that furnace, but still more in the cooling of the walls and bottom, which will take hours of time and tons of fuel to bring back to their normal temperature, delaying for an unreasonable time the next two or three charges, and almost certainly increasing the percentage of copper in the slags.

As it is idle to find fault without suggesting the appropriate remedy, I will describe briefly the method that I always employ when making any of the frequent and comparatively slight repairs that occur every six or eight weeks, and that do not render necessary the complete cooling down of the furnace. I refer to such trifles as building a new flue, putting in a vulcatory or front or side door jambs, or patching the lining of the stack. The day before the job is to be done, I carefully examine the extent of the proposed repairs with the furnace-mason, a man of experience, with whose assistance I can closely estimate the number of brick needed, and, what is of much greater importance, the number that require cutting, and the exact size and shape that they must be cut to.

Noting all this carefully down, I have an ample supply of bricks cut into the shape that will be needed, and when masons and materials are all ready, skim and tap the furnace as clean as possible, throwing in a fresh charge (if the stoppage is to be only of short duration) to protect the workmen from the heat radiating from the bottom, and begin immediately knocking in with long steel bar[illegible] portions of brickwork that are to be renewed, dragging the débris out of the furnace at once with scrapers. The cold charge is especially heaped in that part of the furnace that is to be repaired, and if any portion of the arch is to be rebuilt, it is very easy to form a proper pattern for the purpose by shaping the ore as required. The best and quickest masons should be chosen for this work, and if the job is a very hot one they must be relieved every half hour. In fact, I have found it sometimes necessary to keep a small stream of water playing on the masons' hands, faces, and feet for an hour at a time. If the brickwork or ore is too hot to stand on, nothing makes a better temporary flooring than old planks soaked in copperas liquor, which will remain cool, and will neither catch fire nor smoke. If the fire has been properly banked without being allowed to get too low, the furnace will be in full heat by the second charge, after a stoppage of two hours for repairs.

Smelting in blast furnaces.—The fifth and last division of the Butte processes includes the smelting of copper ores in blast furnaces, which is practiced only at the Bell smelter, though the new Butte Copper Company proposes to do all its smelting in this manner.

I am unable to give accurate details of the Bell furnace. It is a small water jacket, 36 inches in diameter at the tuyeres, and with a capacity of about 40 tons of charge daily, though the quartzose nature of the ore necessitates a heavy proportion of flux, consisting of an excellent limestone and a rather poor quality of bog iron ore. When the calcination has been sufficiently thorough, the matte produced will reach 65 per cent. in copper, but this is seldom attained in practice. I judge that the expense of smelting per ton at these works is about the same as at those where reverberatory furnaces are employed, the high price of coke as compared with coal ($20 to $9) nearly neutralising the advantages commonly claimed for the blast furnace. By increasing the number of tons smelted per day, which could easily be done by putting on a heavy blast, and bricking the fine ore, which constitutes the greater part of the charge, and by diminishing or entirely doing away with barren flux, which can also be very easily accomplished by building a concentrator of sufficient capacity, I am firmly convinced that the blast furnace will hold its own here in comparison with the reverberatory, as it does nearly everywhere else in America when properly managed. So long as toy furnaces, with a capacity of 20 to 40 tons daily, are employed, just so long the reverberatory will take the lead. But when metallurgists learn that a furnace of reasonable size, smelting from 80 to 100 tons a day, will not only work with a less cost per ton for both labor and fuel, but it is also far easier to manage, will average much longer campaigns, and will reduce the cost of repairs from 8 to 6 cents for each ton of ore treated, then the reverberatory will remain in its proper place, which is in Swansea and nowhere else, unless almost similar conditions can be [illegible]d elsewhere as regards price and quality of coal, fireclay, and labor, and a world's ore market to select from. The only other exception, in my humble opinion, would be where, with good fuel and very rich ore, the charge is necessarily so siliceous that in spite of concentration or fluxes the silica contents of the slag cannot be kept below 45 per cent.

The smelting capacity of this district will soon be more than doubled, as the new works of the Anaconda Company, Butte Copper Company, and Clark's Colusa will doubtless be in full operation. It will then be interesting to compare the work done with our present operations, and I feel convinced that the improvements contemplated and partially carried out in the new works just mentioned will more than meet any possible future decline in the price of copper, so that although many of the Arizona mines and a large proportion of the principal copper producers of both Lake Superior and Chili may find it necessary to suspend operations, Butte will still be able to keep every furnace in blast so long as the rich ores, which are still found in undiminished quantities in the lowest workings of the deepest mine, continue. And even if the percentage of the ore diminishes materially, its value in silver (in many cases equaling 3 cents per pound of copper), and the constant cheapening of freight, fuel, materials, and labor, make it probable that Butte's time of prosperity, even if dependent on its copper mines alone, will cover a period of too many years to make it possible to prophesy the time when it will cease to be one of the most important factors of the world's copper market.

THE CUPOLA SMELTING OF COPPER IN ARIZONA.

BY JAMES DOUGLAS, JR.

Furnaces.—The water-jacketed furnace is an actual necessity to the Western smelter, owing to the enormous cost of refractory building material. When the owners of the Longfellow copper mine in Arizona commenced smelting twelve years ago each firebrick cost them $1; and even now at the several furnaces in the Southwest firebricks cost from $100 to $200 per thousand. An indestructible furnace is therefore almost essential to economical success, and this the water-jacketed furnace practically is. It is an expansion of the water tuyere and water back, contrivances which have been long in use. In 1866 J. R. Grout, of the Detroit and Lake Superior Smelting Company, patented a cupola with cast-iron boshes, containing the essential features of the more recent furnace. But the exigencies of the period not requiring it, the general adoption of the water jacket only dates from 1873, when Williams & Daggett introduced it for the smelting of copper and lead ores in Utah.

The type now usually manufactured for copper smelting is that which was designed by Mr. Lewis Williams, who is in charge of the Copper Queen furnaces at Bisbee, Arizona. The eminent success of that mine and its smelting operations gave a great stimulus to the mining of copper in the Southwest, and it was superstitiously believed that some peculiar advantage lay in the particular shape and size of the furnace used by Mr. Williams at the Queen, no matter what the ore to be treated might be. The Pacific Iron Works built the first Queen furnace, but other western and eastern machine shops soon competed for the trade and took out patents for immaterial modifications, advertising their trifling changes in construction as important innovations, and publishing the record of their furnaces when running on some exceptionally fusible ore, as if the quantity smelted were due to the peculiarities of the furnace, when in reality it depended on the character of the charge. No patent covers the use of an inner and outer metallic shell, between which water circulates in quantity sufficient to cool the inner shell, which is in contact with the smelting charge. Every smelter therefore may design a furnace of the proportion and shape he considers best adapted to the ore he has to treat, while any boiler maker may build it without fear of infringing any rights. As the jacket merely replaces the brickwork of the older furnace, it may be made of any shape and size. For siliceous ores it will be made high, for basic ores low. Most are round, and 3 feet in diameter at the tuyeres; but for certain ores the diameter may be advantageously increased. Others are oblong. Generally they have uniformly sloping sides; but one running at the Detroit mine (to be described hereafter in detail) is built with a bosh.

Smelting capacity.—The quantity of ore a jacket of given size will smelt depends upon the fusibility of the charge, the strength of the blast, and the supply of water. The 3-foot round jacket is usually designated as a 30-ton furnace. Under exceptionally disadvantageous circumstances a furnace of that size will smelt only 30 tons; but with fair ore and good management, as at the Queen and elsewhere, it smelts from 45 to 50 tons per day. On the very fusible ore of the Old Globe mine, at Globe, as much as 58 tons have been put through a 3-foot jacket, and even this quantity has been exceeded by a furnace at the Verde.

Unless the ore is refractory, 45 tons of mixture should be smelted under a blast of 10 to 12 ounces, produced by 100 to 115 revolutions of a No. 4½ Baker blower, provided the supply of water is ample. The latter condition is essential. To keep a 3-foot furnace cool under a high blast, from 37,000 to 40,000 gallons of cool water must be passed through the jacket daily, under a head of not less than 10 feet. If the flow be deficient or too hot, steam is generated, the cold water is pressed back, and steam will blow out of the discharge pipe till the jacket is nearly empty. Where enough fresh water to cool the jacket is not available, the hot issuing water must be pumped back and after cooling be returned to the furnace. The cooling is usually effected in a series of tanks. It is more rapidly done by pumping the hot water into a small cistern, elevated 15 feet or so above the receiving tank, through the perforated bottom of which cistern the water falls in streams unimpeded through the air, or better still, upon a brushwood or other open filter, which exposes a large surface to evaporation. When a furnace is first blown in, the iron shell is exposed to the full influence of the heat and more water is required than after the furnace has run a few hours, by which time a coating of slag protects the iron and a rim slightly deflects the blast from the periphery of the furnace. The issuing stream may be almost boiling, but where the water is very calcareous and abundant it is preferred to allow it to flow so rapidly through the jacket that it is only warm when discharged. Much less lime is thus deposited in the jacket and no more fuel is said to be consumed. When the flow of cold water is scanty, and cooling must be resorted to, it is well to couple the pump with the cold-water pipe, so that if the jacket steams obstinately a stream of cold water may be forced through it.

Round furnaces of greater diameter than 3 feet, if the ore is favorable, will smelt more than the smaller ones, though not generally in proportion to their area. Oblong furnaces whose shorter diameter does not exceed 3 feet come nearer to the duty of the small round furnace, area for area, than do large round furnaces. If the ore is not free smelting a furnace of greater diameter than 3 feet is very liable to become deranged, with the formation of a core. If, however, the mixture is fusible and does not contain much fine ore, the blast of a Baker blower, even that of a No. 4½, will penetrate to the center of a 4-foot furnace, though a No. 6 Baker is preferable where furnaces of that size are used. The advantage of a small furnace over a large one is that it is more manageable and if it becomes hopelessly deranged it can be blown in and out at less cost than a large one. On the other hand the record of the Detroit large rectangular furnace shows a slight saving in fuel in the large over the small furnaces, though this is not the case with the large round furnace of the Arizona Copper Company. Up to a certain point the staff necessary to handle the charges and slag of a small furnace would handle a somewhat larger quantity. There is, therefore, always an economy in this item, but unless the ore is very fusible and invariable in its contents this advantage is more than balanced by liability to derangement. In the round 3-foot furnace the cold water is generally admitted by 1½-inch tubing at four different points, two on opposite sides, and the hot water issues by two pipes inserted into the upper flange, rising some inches above the level of the jacket. The slag tap is also jacketed in the Queen furnaces. Where this is not done it is well to have a perforated tube above the slag and metal spouts, through which water may be sprinkled on the spouts and on the copper plates through which the slag and metal are tapped. It is found that crude copper cast in plates 1 inch thick is far preferable to brick for closing the slag and metal openings.

The pipes for admitting the cold water to the furnace should not force the stream against the inner shell, but be curved so as to direct the stream downward. The constant beating against the hot iron plates, especially if the water carries any sediment, rapidly perforates it. Most of the manufacturers have patented contrivances to assist the water in circulating, but unless absolute obstruction be interposed the water circulates without assistance. In building jackets the heads of the rivets should protrude as little as possible into the furnace, and no flange unprotected by water should be exposed to the heat.

Usual plant.—The smelting plant of the Copper Queen, at Bisbee, which is the pattern on which most establishments have been built, consists of:

1. A breaker, with jaws set to open 3 inches, run by a small separate vertical engine.

2. A screen below the breaker with bars ½-inch apart, to sift out fines. At the Globe and elsewhere the ore is dumped on a screen above the breaker and only that portion which is too coarse for the furnace is broken.

3. Bins into which the several varieties of ore are wheeled from beneath the breaker.

4. The Queen runs steadily two (nominal) 30-ton furnaces. This type of furnace is a section of an inverted cone, 3 feet in diameter at the tuyeres and 4 feet 6 inches at the feed door. The body of the furnace for from 6 inches below the tuyeres up to the feed door is built of inner and outer shells, 9 inches apart at the bottom and 4½ inches at the top, closed at top and bottom, within which the water circulates, and to which the water is admitted and from which it is discharged, as already described. The distance from the tuyeres to the feed door is 6 feet, and the total height of the jacket is therefore 6 feet 6 inches. The blast pipe discharges into a wind box, which nearly encircles the furnace and

supplies the tuyeres with a very even blast. A boiler-plate ring about 2 feet deep is riveted to the outer shell of the jacket, and this rests on a cast-iron plate provided with a drop bottom, which plate is supported about 2 feet above the floor of the furnace house on cast-iron pillars. This ring, lined with firebrick, constitutes the crucible of the furnace. The drop bottom is protected with the same material. The slag spout is secured to the crucible shell at the side of the furnace 10 inches below the tuyeres, and the metal spout is in like manner secured to the front of the furnace, 14 inches below the slag spout. The slag and metal openings in the shell are large and are closed by copper plates, each perforated with a small tap hole. Above the feed door the furnace contracts, and consists of an iron shell resting on the outer rim of the jackets, and lined with firebrick. At the Queen works, where much of the ore is soft and clayey, the furnace stacks discharge into a flue 3 feet wide and 96 feet long, provided with hoppers, which effectually catches all dust. In other furnaces the stack expands into a large cone, where, the draft being checked, the dust settles and is discharged through suitable ports. Elsewhere, as at the Arizona Copper Company's works, there is a regular brick dust-chamber. The space between the jacket shells at the bottom is wide enough to allow of the removal of the mud and scale through four hand holes. Where the water is very calcareous, scale accumulates so rapidly as to necessitate blowing down every week. At the Copper Queen the jackets are emptied every five weeks. If a circle of Ludlow gate valves were tapped into the jacket around the base, and these were successively opened to allow a stream of water not greater than that admitted to the jackets, washing out light sediment while heavy scale is being scraped out, the repeated blowing down and stoppage of the furnace might be avoided; which, though it does not cool the crucible, wastes time and coke.

The hood of some furnaces rests on the inner rim of the jacket and is not lined. Even when the hood is lined the number of firebricks which enter the crucible and hood need not exceed one thousand, and unless the charge is unusually basic or yields much matte, the bricks of the crucible need not be replaced during the lifetime of the shell, lute being applied when the furnace is blown out, and clayey ore being dropped in through the tuyeres, if the crucible walls need fortifying.

The rectangular furnace at the Detroit mine and the large round furnace of the Arizona Copper Company depart from the common type.

5. A No. 4½ Baker blower provides blast for each 3-foot furnace. Each blower at the Queen is driven by a separate upright engine, the quantity of blast being controlled by the speed of the engine, instead of by gate valves.

6. Usually six slag pots and four bullion pots are supplied with each furnace, but this number is insufficient. The slag pots wear almost indefinitely, but the bullion pots crack after a few taps, no matter how carefully clayed and heated before use. They are then strengthened by bands. It would probably be better to cast them in sections, mak-

ing the joints along the lines of greatest strain. At the Detroit works a copper core is cast in a pot of the usual size, and this is suspended in a larger pot, so that a space of 1½ inches intervenes between the core and the sides of the pot. Into this space copper is tapped, and thus a copper lining is secured which protects the iron wagon from the direct action of the hot metal. At the Queen slag is tapped every five or seven minutes, and the metal is run every half hour into bars averaging 250 pounds.

7. If there is an abundance of flowing water no tanks are required; otherwise, as at the Queen, a receiving tank, a pump, and cooling tanks form necessary additions to the plant.

8. At the Copper Queen Mr. Williams passes the slag from the furnace to the slag pots through an outer well 4 by 2½ by 2½ feet deep, made of cast-iron plates and mounted on wheels. The wells are lined with a plaster of clayey ore, and remain open for from twenty-four to forty-eight hours. Each well yields about 100 pounds of copper a day, besides what is entangled in the chilled slag. As the slag is tapped from the column of smelted ore, through which the particles of metal are constantly descending, it is inevitable that more or less metallic copper should issue with it. The outer well saves a portion of this mechanical loss, but as some of these almost invisible particles of copper in flowing into the well from the tap hole come into contact with the air and are oxidized, it is better to attach a settling well to the furnace itself and tap from it. This is done at the San Carlos establishment by bolting to the iron shell of the crucible a boiler-plate box 2½ feet long by 2 feet wide by 2 feet deep, supported on a pillar and furnished with a slag spout. The box is lined with brick, like the crucible of the furnace, the bottom sloping upwards from the level of the metal tap to that of the slag tap. This is covered by copper plates, which can be readily removed and replaced if the well requires to be cleared of chilled slags. It answers admirably the purpose intended without deranging the working of the furnace. Were it covered by a water-jacketed plate provided with a curtain which would dip below the surface of the slag at the discharge end of the well, like the tymp of the older furnaces, a continuous flow of slag might be secured.

9. The fine ore from beneath the grizzly, the dust from the flue, with the more clayey ore from the mine, are molded by hand into bricks with coke screenings after mixing in an ordinary pug mill. At the Detroit works, at Morenci, a brick press is used; and at the Arizona Copper Company's works, at Clifton, milk of lime is added to give greater coherence to the dust.

Operations at the Copper Queen.—The furnace operations at the Copper Queen have been marked by greater regularity in running and consequent uniformity of production, both as to quantity and quality, than those of any other establishment in Arizona. The following record from January 1 to October 31, 1884, gives the history of each of the two furnaces during that period:

Operations of furnace No. 1 at the Copper Queen mine, from January 1 to October 31, 1884.

Date, week ending—	Ore smelted.	Bricks smelted.	Total smelted.	Copper produced.	Copper yielded by ore and bricks.	Copper in slag.	Coke used.	Coke per ton of ore.		Coke per ton of copper.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*
January 7	542,[illegible]	97,[illegible]	[illegible]	[illegible]	10.[illegible]	1.79	126,[illegible]	19.[illegible]	365.4	1[illegible].0	3,[illegible]
January 14	[illegible]	73,250	[illegible],610	70,515	10.70	1.[illegible]	[illegible],900	18.97	377.6	177.3	3,[illegible]
January 21	644,[illegible]	18,270	[illegible],870	70,[illegible]	10.[illegible]	1.[illegible]	131,[illegible]	19.[illegible]	3[illegible].6	1[illegible].0	3,[illegible]
January 28	590,[illegible]	58,[illegible]	647,[illegible]	[illegible]	10.[illegible]	1.45	[illegible],345	19.[illegible]	3[illegible].6	178.9	3,[illegible]
February 4	643,070	34,[illegible]	670,[illegible]	71,[illegible]	10.51	1.10	[illegible]	19.79	370	176.0	3,[illegible]
February 11	[illegible]	8,500	[illegible]	[illegible]	[illegible]	1.44	[illegible]	18.21	3[illegible]	1[illegible].4	3,[illegible]
February 18	[illegible]	25,000	[illegible]	72,[illegible]	10.[illegible]	1.45	[illegible],910	18.[illegible]	375.8	177.9	3,[illegible]
February 25	[illegible]	61,[illegible]	[illegible]	77,[illegible]	11.72	1.[illegible]	[illegible]	19.44	3[illegible].3	1[illegible].7	3,[illegible]
March 3	590,[illegible]	94,[illegible]	674,[illegible]	[illegible]	11.[illegible]	1.07	[illegible]	18.20	3[illegible]	181.6	3,[illegible]
March 10	622,[illegible]	35,100	657,900	[illegible]	10.[illegible]	.87	[illegible]	18.[illegible]	378.0	1[illegible].3	3,[illegible]
March 17	601,[illegible]	70,[illegible]	672,[illegible]	[illegible]	11.[illegible]	.[illegible]	[illegible]	18.19	3[illegible].2	178.4	3,[illegible]
March 24	[illegible]	91,500	[illegible],100	70,[illegible]	10.[illegible]	.[illegible]	[illegible]	18.56	371.4	171.6	3,[illegible]
March 31	587,700	[illegible],500	[illegible]	[illegible]	10.[illegible]	.91	[illegible]	18.[illegible]	372.3	167.6	3,[illegible]
April 7	618,[illegible]	70,500	[illegible],400	[illegible]	11.[illegible]	.[illegible]	[illegible]	18.73	3[illegible].4	1[illegible].9	3,[illegible]
April 14	579,[illegible]	78,[illegible]	[illegible],300	[illegible]	11.57	1.07	[illegible]	18.[illegible]	367.6	161.7	3,[illegible]
April 21	[illegible],710	84,440	667,[illegible]	74,[illegible]	11.13	.[illegible]	[illegible]	18.[illegible]	376.4	1[illegible].0	3,[illegible]
April 28	588,[illegible]	126,[illegible]	[illegible]	[illegible]	11.[illegible]	1.[illegible]	[illegible]	17.04	3[illegible].8	1[illegible].5	3,1[illegible]
May 5	569,270	95,[illegible]	[illegible]	70,[illegible]	10.[illegible]	.[illegible]	[illegible]	18.55	371.2	169.1	3,[illegible]
May 12	561,[illegible]	82,[illegible]	[illegible]	[illegible]	10.12	.[illegible]	[illegible]	18.[illegible]	347.4	178.0	3,[illegible]
May 19	575,643	[illegible],700	670,[illegible]	[illegible],910	10.41	.75	[illegible]	18.97	372.5	178.9	3,[illegible]
May 26	570,730	[illegible]	[illegible]	[illegible]	10.91	.[illegible]	[illegible],213	18.[illegible]	377.8	174.7	3,[illegible]
June 2	542,170	[illegible],500	641,[illegible]	[illegible]	10.[illegible]	.[illegible]	[illegible]	19.22	3[illegible].6	164.0	3,[illegible]
June 9	541,440	106,[illegible]	[illegible],400	[illegible],175	11.[illegible]	.[illegible]	[illegible]	19.05	361	1[illegible].9	3,[illegible]
June 16	563,470	106,400	[illegible],870	[illegible]	11.[illegible]	1.07	[illegible]	19.13	361.6	167.6	3,[illegible]
June 23	644,[illegible]	134,[illegible]	[illegible]	[illegible]	11.[illegible]	1.[illegible]	[illegible]	18.94	378.2	167.9	3,[illegible]
June 30	[illegible],601	131,[illegible]	[illegible]	87,[illegible]	12.40	1.27	131,[illegible]	17.41	3[illegible].6	1[illegible].7	3,[illegible]
July 7	518,911	84,[illegible]	[illegible],911	70,[illegible]	10.[illegible]	1.11	[illegible]	18.[illegible]	3[illegible].3	121.5	3,[illegible]
July 14	612,021	108,[illegible]	720,101	[illegible]	10.[illegible]	1.[illegible]	[illegible]	17.21	344.1	107.5	3,[illegible]
July 21	[illegible]	[illegible],120	712,215	72,[illegible]	10.[illegible]	1.[illegible]	[illegible]	17.78	3[illegible].4	171.5	3,[illegible]
July 28	[illegible],714	97,100	[illegible],574	81,[illegible]	10.[illegible]	1.[illegible]	[illegible]	17.[illegible]	3[illegible].9	148.9	3,[illegible]
August 4	587,303	106,[illegible]	[illegible],442	[illegible],100	11.[illegible]	1.[illegible]	114,[illegible]	18.70	3[illegible].9	147.1	3,[illegible]
August 11	[illegible],018	78,120	[illegible]	[illegible]	9.[illegible]	1.[illegible]	[illegible]	18.[illegible]	3[illegible]	172.0	3,[illegible]
August 18	670,[illegible]	112,[illegible]	[illegible]	[illegible]	10.[illegible]	1.10	[illegible]	18.[illegible]	3[illegible].8	1[illegible].0	3,[illegible]
August 25	[illegible]	[illegible],400	[illegible]	[illegible]	9.[illegible]	1.[illegible]	[illegible]	17.[illegible]	3[illegible].4	1[illegible].1	3,[illegible]
September 1	[illegible],130	[illegible],940	718,[illegible]	[illegible]	10.[illegible]	1.[illegible]	[illegible]	16.91	3[illegible].7	1[illegible].0	3,[illegible]
September 8	691,511	58,[illegible]	745,[illegible]	[illegible]	12.[illegible]	1.31	[illegible],771	16.[illegible]	316.8	1[illegible].1	3,[illegible]
September 15	645,[illegible]	77,100	[illegible]	[illegible]	12.[illegible]	1.[illegible]	[illegible]	16.[illegible]	321.2	1[illegible].1	3,[illegible]
September 22	[illegible]	[illegible],400	[illegible]	[illegible]	12.[illegible]	1.[illegible]	114,[illegible]	16.[illegible]	3[illegible].4	11[illegible].9	3,[illegible]
September 29	678,[illegible]	87,[illegible]	761,[illegible]	111,[illegible]	14.[illegible]	.[illegible]	114,[illegible]	16.01	301.6	1[illegible].2	3,[illegible]

October 6	718,700	42,500	760,200	102,245	13.46	1.08	118,260	16.13	302.2	110.3	2,[illegible]
October 13	736,900	....	736,900	90,735	12.43	1.10	116,791	16.00	252.5	128.5	2,[illegible]
October 20	737,400	15,900	753,300	98,135	12.94	1.10	112,[illegible]	14.94	290.0	130.0	2,410
October 27	714,000	42,900	757,500	97,185	12.81	1.43	109,373	14.44	[illegible]	112.8	2,[illegible]
October 31	345,000	45,800	390,000	44,180	11.29	1.43	66,677	11.15	348.4	134.3	2,731
	26,734,474	3,270,814	30,004,568	3,[illegible],302	11.24	1.18	5,216,070	16.85	282.4	136.6	2,[illegible]

Operations of furnace No. 2 at the Copper Queen mine, from January 1 to October 31, 1884.

Date, month ending—	Ore smelted.	Bricks smelted.	Total smelted.	Copper produced.	Copper yielded by ore and bricks.	Copper in slag.	Coke used.	Coke per ton of ore.		Coke per ton of copper.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*
January 31	2,[illegible],410	377,000	2,911,570	288,725	10.00	1.07	560,258	19.22	384	191.7	3,[illegible]
February 29	2,[illegible]	169,340	2,825,[illegible]	304,315	10.70	1.41	533,500	18.81	376	175.2	3,[illegible]
March 31	2,673,840	354,000	3,027,840	330,405	10.[illegible]	.92	594,658	19.65	373	171.6	3,[illegible]
April 30	2,516,930	389,210	2,906,140	324,705	11.14	1.06	532,140	18.31	366	164.3	3,[illegible]
May 31	2,520,100	424,280	2,944,380	307,793	10.42	.88	547,201	18.59	372	178.8	3,[illegible]
June 30	2,394,[illegible]	468,650	2,862,[illegible]	333,[illegible]	11.65	1.07	535,[illegible]	18.70	370	161.3	3,[illegible]
July 31	2,644,540	427,560	3,072,100	331,395	10.74	1.57	524,054	17.07	341	158.7	3,[illegible]
August 31	2,[illegible],701	298,550	3,125,041	314,940	10.11	1.36	534,[illegible]	18.77	[illegible]	165.0	3,[illegible]
September 30	2,941,[illegible]	228,500	3,170,[illegible]	422,[illegible]	13.32	1.30	560,118	18.77	316	119.8	2,[illegible]
October 31	2,961,150	144,650	3,105,[illegible]	396,720	12.57	1.23	495,846	16.15	326	120.3	2,[illegible]
Total	26,[illegible],165	3,[illegible]	29,[illegible],165	3,375,[illegible]	11.21	1.27	5,316,190	17.70	355	160.40	3,[illegible]

Furnace No. 1 had been in blast two years on September 15, 1884. During that period its crucible had never been cooled. It had been blown down every five weeks to clear out the lime scale from the jacket, but each operation occupied, from the blowing down to the refilling, only three hours. Once this interruption was extended to six hours, when a patch was riveted to the inner shell opposite to one of the water pipes. No. 2 furnace had been continually in blast since May, 1883. During these long campaigns not a brick had been used in repairs. Both furnaces are of the same size and pattern, the only difference being in the diameter and dip of the tuyeres. Those of furnace No. 1 are 5 inches in diameter and have a slight dip; those of No. 2 are 4 inches in diameter and are set horizontally. The blower of furnace No. 1 is run at 115 revolutions; that of furnace No. 2 at 105, to maintain a pressure of about three-fourths of a pound. The furnace record shows a decided advantage in favor of the 5-inch tuyere, the slags being cleaner and the amount of ore smelted being greater.

The coke used is from Trinidad, Colorado, and San Pedro, New Mexico. The latter is freer from ash but more friable than the former. The consumption of coke is large, 1 part to 5.9 parts of wet ore, as fed into the furnace. The ore contains on an average not less than 10 per cent. of moisture. The charge requires to be occasionally fluxed, but generally a judicious mixture of ores from the several levels, which yield ores of very different composition, relieves the furnace from any barren material.

The furnace staff consists of a day and a night foreman, twelve hours each, over both furnaces. To operate each furnace:

No.	Class.	Length of shift.
		Hours.
3	Ore wheelers	8
2	Coke wheelers	12
3	Feeders	8
3	Tappers of slag and metal	8
4	Helpers, wheeling slag and metal	12

The ore wheelers and coke wheelers are Mexicans. One Mexican is employed in the coke yard in cleaning bullion and wheeling up slag to the feed floor. One Mexican and six boys are intermittently employed making bricks (adobes). The furnace charges weigh 300 pounds, the ore, slag, flux (when used), and coke being carefully weighed on platform scales at the feed door. If the charge is unusually basic the crucible becomes thin and the iron casing and drop bottom too hot. The crucible is then emptied, and fine clay ore is inserted by a scoop through the tuyeres, until the crucible lining is sufficiently built up. If, on the other hand, the bottom rises, the blast is occasionally allowed to blow for a few minutes through the metal tap. A hammer is seldom used in tapping, and a bar never enters the tuyeres, an iron plug being inserted, which arrests the blast as soon as chilling is perceived at any point. The long campaign of these furnaces, their absolute freedom from accident, and the small bill of repairs, are due to the skill and the watchfulness of Mr. Lewis Williams.

The last annual report of the Copper Queen Company, made by Mr. Benjamin Williams, the superintendent, shows that since the commencement of operations in the summer of 1880 until April 1, 1884, there were smelted 89,385 tons of ore, yielding 12,048 tons of black copper, of an average percentage of 96.50 by fire assay, or 13.45 per cent. of black copper to the ton of ore. This large yield was produced by one 3-foot furnace for the first year and by two furnaces subsequently. A spare jacket is always ready, but it is not deemed necessary to keep a third furnace set up, as accidents are rare, and when a jacket is worn out it can be quickly removed and replaced by another.

The following analysis of samples of slag taken over a period of several months indicates the character of the charge, which consists of calcareous surface ores carrying chiefly green carbonates, brecciated clays, silts saturated with carbonates, and massive iron oxides impregnated with cuprite, which are intercalated among the clays in the lower levels of the mine.

Analysis of Copper Queen slag.

	Per cent.
Silica	26.64
Protoxide of iron	42.00
Manganese	0.90
Zinc	0.50
Lime	9.51
Magnesia	0.30
Alumina	15.40
Copper, carbonic acid, etc	4.85
	100.00

Old Dominion Copper Company.—The second largest producer of copper during the last two years has been the Old Globe mine, at Globe, worked by the Old Dominion Copper Company, of New York City. The output has in some months considerably exceeded that of the Copper Queen. The total production for 1884 was 7,396,725 pounds of copper from 23,362 tons of ore, which therefore yielded 15.83 per cent. The assay value of the ore was 17.33 per cent. The plant contains three furnaces, all of which are seldom run together. In construction the plant does not in any important feature differ from that of the Copper Queen, at Bisbee, and the furnaces are run on the same system. The ore, however, being more ferruginous, a more fusible mixture can be economically made. The 3-foot jacket has there put through as much as 56 tons daily. The experiment of running a 3-foot furnace with two No. 4½ blowers was made, but resulted in an increased duty of only 4 tons per day.

Works of the Detroit Copper Company and the Arizona Copper Company.—At Clifton is the large smelting plant of the Arizona Copper

Company, the nearest of whose mines, those of the Longfellow group, are adjacent to those of the Detroit Copper Company, 5 miles distant up Chase creek. The Detroit Company's smelting works are at its mines, where the little town of Morenci has grown up. Both establishments have substituted large for small furnaces.

The old smelting works of the Detroit Company were on the San Francisco river, 5 miles below Clifton and 7 miles from the company's mines, which are at an elevation of 1,450 feet above the river and in a perfectly sterile region. The furnaces on the San Francisco were run by water power, but as the cost of transporting ore by teams was considerable and the interruptions frequent, it became necessary either to connect the mines with the works by a railroad or to move the furnaces to the mines and pump thither the water with which to cool the jackets. The latter alternative was decided on. The power which formerly ran the furnaces, a 44-inch Leffel turbine, under a 10-foot fall, is now applied to a powerful pump. The pump was designed by H. R. Worthington, and combines as perfect simplicity of form as is compatible with the strength necessary to a very heavy lift. It has four single-acting water plungers, 5½ inches in diameter, 15-inch stroke, that make it equal to two double-acting pumps. The valve chambers are multiplied. They can thus be small and separate, easily replaced, and be much stronger than one subdivided chamber would be. The pump was designed to throw 100,000 gallons per day, at twelve strokes per minute, through a 4-inch pipe, to an elevation of 1,510 feet and a distance of 7 miles against a pressure calculated at 750 pounds per square inch. The tubing between the pump and the mine is the ordinary 4-inch lap-welded pipe with extra heavy connections and valves at the bottom of the column. The pump is not run faster than nine strokes per minute; at that speed the requirements of the camp and furnaces are more than satisfied. Running at from five to six strokes the pressure gauge indicates from 640 to 670 pounds. The actual elevation from the pump to the top of the store tanks, which are some distance above the furnaces, is 1,540 feet.

There is one other instance in Arizona where pumping has replaced the transport of ore. The Arizona Central (the old Vulture) gold mine pumps the water for an 80-stamp mill from the Hassayampa, a greater distance but to a less elevation. Steam power is there used, yet the cost is only 25 cents per ton of ore stamped against $4 for haulage. The economy of throwing water over transporting ore is so self-evident that it should be oftener practiced. As pumps and tubing can be built to withstand almost any strain, and are operated in the oil region under a pressure of over 1,000 pounds to the square inch, the localities where the system can be applied are very many. The makers state that the type of pump above described has proved itself perfectly capable of dealing with pressures as high as 5,000 to 6,000 pounds per square inch.

The Detroit smelting works are connected with the company's mines and with the Arizona Copper Company's tramway to Clifton, and with the terminus of the branch railroad to Lordsburg, by a system of 20-inch gauge tramways. Thus all wagon hauling and unnecessary handling of ore, coke, or bullion is avoided. As the companies have adjacent mines the mine roads have been built jointly and are used by both—an example of harmonious co-operation worthy of imitation. The mine tramways, on which two engines are kept busy, are 1½ miles in length and traverse 2,300 feet of tunnels.

At the Detroit works two furnaces are erected, one the usual 3-foot round stack, the other a large rectangular furnace, with a bosh, designed by Mr. Carl Henrich, the late metallurgist. The cross section at the tuyeres is 33 by 66 inches, which it maintains for 10½ inches upward, then the sides slope rapidly, so that at 30 inches above the tuyeres and 3 feet above the slag tap the cross section is 45 by 78 inches. Here the lower jackets, four in number, terminate, and the upper four jackets, 5 feet high, rest on them, with a lower pitch, so that at 8 feet above the slag tap the section is 54 by 87 inches, which size is retained to the feed door, 11 feet above the slag tap. The crucible is 14 inches deep, is brick lined, and is provided with a drop bottom.

The furnace was built with an adjustable modification of the bell and hopper automatic feed, but it had to be taken out, as it was found to size the ore and throw an undue quantity of fines either to the rim or center as the case might be. Mr. Henrich adopted the bosh, believing that by reducing more iron he would clean his slags, an inference which seems to have been borne out by the short experience as yet had; but the furnace shows a greater liability to scaffold than the usual inverted-cone type. It is provided with fourteen tuyeres, five on each long side and two at each end. The tuyere gates are 9-inch vertical slots, and the tuyeres are connected by canvas bags with the blast pipes, and can be adjusted both as to height and pitch, as in the Western lead furnace The tuyere openings are only 2¾ inches. The blast is supplied by two No. 4½ Baker blowers, run at 115 revolutions to produce a pressure of 10 ounces. A larger quantity of air would probably increase the efficiency of the furnace to 100 tons per twenty-four hours, which its large area calls for. The slag is tapped from both ends, the metal from the middle.

The record of twenty-six days' run in November, 1884, is as follows:

Record of the Detroit large furnace, November, 1884.

Beds.	Weights.		Copper in ores.	Copper produced.	Copper saved.	Copper in slag.	Colorado coke used.	Fuel ratio.
	Pounds.	*Per ct.*	*Pounds.*	*Pounds.*	*Per ct.*	*Per ct.*	*Pounds.*	
Ores	[illegible]	14.87						
Iron	[illegible]	5.66						
Total ores	4,116,145	12.71						
Limestone	[illegible]							
Total charged	4,428,770	11.86	[illegible]	[illegible]	[illegible]	1.11	[illegible]	1 to [illegible]

Or dry ore and flux smelted per day, [illegible] tons; black copper produced, [illegible] pounds per day.

The record shows a reduction of the copper in the slags of about 0.4 per cent. under the average working of the 3-foot round furnace, and a saving in coke of about 8 per cent., the consumption of San Pedro coke by the small furnace being about 1 to 6 of smelting mixture. When Cardiff patent pressed coke is used the small furnace consumes only 1 to 8. Tennessee coke is about to be tried at these furnaces, when comparison can be made between the coke from Trinidad, Colorado; San Pedro, New Mexico; Cardiff, Wales; Connellsville, Pennsylvania; and Tennessee.

The labor employed about this furnace is:

Above: When using the automatic feeder: 6 coke and ore wheelers (length of shift, 8 hours); 2 weighers (12 hours).

Their place is taken by 3 feeders (8 hours) when the automatic feed is not used.

Below: Three metal tappers and wheelers (eight hours); 6 slag tappers and wheelers (eight hours).

Were the capacity of the furnace increased to 100 tons daily the present staff would not be able to overtake the work. Yet the labor is less per ton of ore treated than is necessary to handle the small furnace, running say 40 to 50 tons a day. As the area of the large furnace is as 15 to 7.06 compared with that of the 3-foot furnace, it should smelt about 100 tons. Mr. Church, who is both manager and president of the company, introduced another modification into the works, which is a decided improvement. Instead of a number of small engines, he uses one 12 by 36-inch Corliss engine, built by Fraser & Chalmers. It consumes only 1¾ cords of wood per day in running the two blowers, rock breaker, sampling mill, elevator, etc. Its speed is, of course, invariable. All the coke screenings, which are however trifling when English coke is used, are burnt under the boilers. The blast of the furnace is regulated by gate valves.

The ores to be smelted come from four claims, and are very different in character and variable in composition. They are consequently made into beds, 15 feet wide by 36 feet long, containing 250 tons each, the contents of which are carefully sampled before use, and any deficiency in base is made up from the flux bins. The following analysis of the average sample of slags was made by Mr. S. James, jr.:

Analysis of Detroit slag.

	Per cent.
Silica	34.34
Protoxide of iron	32.27
Manganese	6.24
Lime	10.25
Magnesia	2.30
Alumina	11.04
Copper, carbonic acid, alkalies, etc	3.56
	100.00

The Arizona Copper Company's works at Clifton far exceed in size any in the Southwest. They are built at the junction of the Chase Creek cañon, through which the company's railroad conveys the ore from their mines to the San Francisco river, which supplies water power. The railroad tracks to distribute coke and ore at appropriate levels are laid on terraces cut out of the rock, and the cars are discharged into four rows of coke and ore bins. A switch enters the bullion yard. The plant consists, besides, of two large rock breakers, three round furnaces 4 feet in diameter, two round furnaces 3 feet in diameter, three No. 7 Baker blowers, one No. 5 Baker blower, one No. 4½ Baker blower.

The works are run by water power during the greater part of the year, which can be supplemented by steam power in the dry season. As yet the whole battery of furnaces has not been in blast at one time. They have a total capacity of 300 tons of smelting mixture a day. Here large and small furnaces are run side by side, and Mr. Colquhoun, the metallurgist, gives his verdict unhesitatingly in favor of the small ones. He does not find the large furnaces more economical in fuel than the small, nor do they do cleaner work, while their greater liability to derangement more than compensates for a slight economy in the item of labor.

The large furnaces had jacketed crucibles lined with brick, till Mr. Colquhoun, attributing much of the faulty action of the furnaces to the chilling effects of the water where not needed below the zone of fusion, turned it off. The result was an immediate increase in duty from 60 to 75 tons of smelting mixture per day.

The charges of both the large and the small furnaces are alike, 730 pounds, this large charge being preferred as it reduces the errors in weighing, though the experience of other works favors smaller and often-repeated charges.

When Connellsville coke alone is used it is consumed in the proportion of 1 to 7.75 of mixture, while Cardiff patent coke smelts at the rate of 1 to 8.33. The ores of the whole region, except those of the Longfellow and Copper Mountain mines, in which large quantities of iron and manganese accompany the copper, are siliceous and aluminous, the carbonates and oxides being inclosed in decomposed feldspathic rocks. Both the Detroit and Arizona copper companies have therefore to use flux liberally.

Both works also make matte occasionally, which is also the case with the Copper Queen. At the Arizona Copper Company's works the pigs are dumped into water, which facilitates the removal of adhering matte and slag.

The United Verde Copper Company.—The only other establishment in Arizona producing copper largely is that of the United Verde Company. It has consisted heretofore of one 3-foot furnace, but another is now being erected. The ores treated are more argentiferous than any smelted in Arizona, the silver constituting a large proportion of the value of the bullion. The furnace went into blast in July, 1883, and ran 119⅜ days in that year, during which time it turned out 1,004 tons of bullion and matte, containing 940 tons of fine copper and 125,000 ounces of available silver, from 5,004 tons of ore. The consumption of Colorado and English coke mixed was 1,018 tons, or nearly exactly in the ratio of 1 to 5.

In 1884 the furnace ran for 231½ days. The product was bullion 1,268 tons, containing 1,208 tons of refined copper and 134,676 ounces of silver, and 839 tons of matte, containing of refined copper 551 tons and of silver 25,416 ounces. This product was recovered from 12,067 tons of ore, which therefore yielded to the furnace 14.6 per cent. of copper. The bullion now coming forward contains also a noteworthy amount of gold.

On the Colorado river, above Yuma, copper was mined twenty years ago at the Planet and other mines, and was shipped as ore to California. A smelter has recently been erected to reduce the ore of these old mines, and has shipped some bullion; but the very low price of copper makes it difficult to work a lean ore to a profit, no matter how cheaply it can be mined.

No discoveries of new copper mines were made in 1884. Two new smelting works were started in new localities, though on old locations, but were soon shut down after producing a few car loads of bullion, and there are no projects on foot for the establishment of others. There is therefore no present prospect of any notable increase in the production of Arizona; but, on the other hand, there are no symptoms of any falling off, for never at any of the above named districts were more oxidised ores in sight than at present. The low price of copper of course reduces the profits, but this is being partially counterbalanced by reductions in every item of cost. The value of copper bullion shipped from Arizona exceeded in 1884 that of her gold and silver production, while its bulk and the freightage on the consumed coke render it as an article of export far more necessary to the prosperity of the railroads competing for the traffic of the Territory than many times its value in the precious metals. All interests and classes, therefore, are united in fostering an enterprise which has become an integral part of the industrial life of the Southwest Territories, and all therefore combine to help the Arizona copper miner and smelter to hold his own against all competitors in the present fierce struggle for existence.

While the copper from Copper Queen, Clifton, and Old Globe is remarkable for its freedom from arsenic, antimony, and other deleterious substances, the same is not true of all Arizona copper, nor even of copper made from other mines in the immediate neighborhood of some of these mines, but the Copper Queen and some other brands are so remarkably pure as to have acquired a high reputation both in the American and European markets. All the furnaces turn out bars of about equal tenor in copper, namely, 97 to 98 per cent. by wet assay.

[A paper by Mr. Henry M. Howe, on "Copper Smelting," prepared for this volume, has been omitted for lack of space, and is published separately as a bulletin of the United States Geological Survey.]